

Figure 6 - 11

**Design of Typical Deep
Multi-Port Groundwater
Monitoring Well**

During the field activities as new data are generated, they will be compiled, evaluated and compared to the existing data. During the field activities, the data will be discussed with the agencies (EPA, DTSC, and RWQCB) to help identify data gaps and determine which gaps, if any, need to be filled. If required, additional wells may be installed and other data may be obtained as required during the latter stages of the RI.

A draft report will be produced to present the analytical data, data evaluations, and conclusions from the RI for OU-1. The general outline for the draft OU-1 RI report is presented in Table 6-3.

6.1.3 OU-1 Groundwater Baseline Risk Assessment

Objectives for the investigation of OU-1 for the Baseline Risk Assessment (BRA) include identification of potential chemicals of concern (COCs), potential source areas and release mechanisms, receptor exposure pathways, and additional data requirements. Each of these OU-1 risk-assessment parameters have gone through a preliminary evaluation, the results of which are briefly summarized below. Further evaluation of these parameters will be performed during BRA.

Potential Chemicals of Concern

Based on existing information, VOCs were likely released to groundwater during past JPL disposal practices. These disposal practices apparently included disposing of spent solvent into on-site seepage pits. The primary contaminants that have been previously detected in the groundwater at JPL include the following:

- Carbon tetrachloride
- Trichloroethene (TCE)
- 1,1-Dichloroethene
- Tetrachloroethene (PCE)

These VOCs comprise a partial list of constituents of interest for OU-1.

Potential Source Areas and Release Mechanisms

Potential sources of groundwater contamination include past waste-disposal pits and currently contaminated subsurface soils. Infiltration of precipitation through soil may cause contaminants in subsurface soils to migrate toward and leach into groundwater. Since groundwater underlying

TABLE 6-3

OUTLINE OF OU-1 REMEDIAL INVESTIGATION REPORT

-
1. Introduction
 - 1.1 Purpose of Report
 - 1.2 Site Background
 - 1.2.1 Site Description
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 - 1.2.3 Previous Investigations
 - 1.3 Report Organization
 2. On-site Groundwater Investigation
 - 2.1 Installation of Wells
 - 2.2 Groundwater Sampling Procedures
 3. Physical Setting
 - 3.1 Physiography
 - 3.2 Meteorology
 - 3.3 Geology
 - 3.3.1 Stratigraphy
 - 3.3.2 Structure
 - 3.4 Hydrogeology
 - 3.4.1 Hydraulic Characteristics
 - 3.4.2 Groundwater Flow System
 4. Nature and Extent of Contamination
 - 4.1 Groundwater Quality Analyses
 - 4.1.1 Quality Assurance/Quality Control
 - 4.2 Plume(s) Definition
 5. Contaminant Fate and Transport
 - 5.1 Contaminant Migration
 - 5.1.1 Conceptual Model
 6. Baseline Risk Assessment
 - 6.1 Human Health Evaluation
 - 6.1.1 Exposure Assessment
 - 6.1.2 Toxicity Assessment
 - 6.1.3 Risk Characterization
 - 6.2 Environmental Evaluation
 7. Summary and Conclusions
 - 7.1 Summary
 - 7.1.1 Nature and Extent of Contamination
 - 7.1.2 Fate and Transport
 - 7.1.3 Risk Assessment
 - 7.2 Conclusions
 - 7.2.1 Data Limitations and Recommendations for Further Work
 - 7.2.2 Recommended Remedial Action Objectives
 8. References
-

the site is not brought to the surface, significant releases to other media are not likely under current conditions.

Human Receptors and Exposure Pathways

The groundwater underlying the site is not currently being used. Therefore, no human population is expected to be exposed to the OU-1 groundwater. Future use of this groundwater is possible and will, therefore, be considered in the BRA. Note that this groundwater is being utilized in OU-3. This will be discussed in Section 6.3 on OU-3 off-site groundwater.

Ecological Receptors and Exposure Pathways

The groundwater table has been measured between approximately 50 and 240 feet below ground surface at various locations across the JPL site depending on the topography. Accordingly, because of relatively significant groundwater depth, ecological receptors are not currently expected to come in contact with groundwater underlying the site. Further ecological receptor evaluation is planned for this phase of the RI.

Summary of Additional Data Requirements

The following additional data is needed to support the health risk assessment:

- Determine if OU-1 groundwater will be used for process water or any other purpose.
- Underlying groundwater should be characterized to determine the nature and extent of contamination.
- Contaminant transport patterns in groundwater should be investigated.

6.2 OPERABLE UNIT 2 RI FOR SOURCE CHARACTERIZATION

The RI for Operable Unit-2 represents the effort to identify, confirm, and verify the location and extent of vadose-zone soils (soils between the ground surface and the top of the groundwater table) impacted by wastes generated at JPL both north and south of the JPL Thrust Fault. Identification of known or suspected areas of soil contamination through document research and field exploration were major efforts during the pre-RI activities.

The OU-2 RI will continue to verify the extent of waste impact both north and south of the JPL Thrust Fault at known areas and confirm suspected areas of waste impacted soil. This effort will support the OU-1 RI as the impacted vadose-zone soil is believed to be the source of groundwater contamination. A source-characterization investigation will continue to be developed according

to the EPA DQO process using a staged approach to meet the goals of the RI/FS program. The following sections on the OU-2 RI program components will discuss data quality objectives (DQO Stages 1 and 2), site characterization, risk assessment, and sampling strategies (DQO Stage 3).

6.2.1 Data Quality Objectives for OU-2

Data developed for the on-site source characterization, or OU-2, will be used for further risk assessment, site characterization, and support for evaluation of remedial alternatives and design. The primary data requirements for the source characterization involves further defining the horizontal and vertical extent of known and suspected sources of contaminants in the vadose zone. A number of surficial changes have taken place over the years at JPL involving building construction and demolition, erosion and excavation. It suspected that some of these changes have occurred in areas that may have been used for waste disposal. Therefore, for the RI, a variety of sampling methods will be used to fully characterize known and suspected contaminant sources, such as soil vapor surveys, soil borings, and soil vapor monitoring. Discussions of previous source characterization activities and results are presented in Section 5.0.

EPA Level IV data procedures will be used when sampling for COCs. To facilitate the RI/FS process, these data will be reported using EPA Level III documentation. The sampling, data handling, and laboratory sample control procedures are described in more detail in the OU-2 FSAP and the JPL RI/FS QAPP. During the OU-2 field sampling activities, 100 percent of the samples collected and analyzed will be transmitted to the laboratory with instructions to deliver EPA Level IV data for those samples.

Collection and evaluation of source-characterization data will be subject to the RI/FS DQO process where the overall objectives in completing the OU-2 RI are an iterative process. This means that as field activities proceed and background and laboratory data are evaluated, the specific targets of the RI program will be reassessed and adjusted until data gaps are filled and a complete RI is accomplished.

DQO Stage 1 activities previously undertaken included interviews with former and current employees and search of microfiche files for drawings related to any structure or activities that might indicate source areas. These preliminary activities were discussed during scoping meetings with the regulatory agencies and NASA. During the pre-RI field explorations, a shallow soil-vapor survey and a soil-boring program were conducted at selected locations, and some of the soil-vapor samples had VOC presence (see Table 5-21, Section 5.2.1).

In order to successfully complete the OU-2 RI, these field activities will be resumed so that the extent of the contaminant sources and impact on the vadose zone will be known. COCs in the impacted areas of the vadose zone present a potential threat to human health and the environment at the surface and in the subsurface during excavations and upon entry to the groundwater system.

The need exists to further identify sources of soil contamination and chemicals that have impacted the soil and groundwater. Hot spots that are identified will undergo further investigation and sampling. Prior field activities have focused on only a few specified source locations. The need remains for confirmation of other suspected source areas.

Soil-vapor wells will be constructed in previously sampled soil borings at select hot spots to facilitate long-term monitoring. Long-term monitoring will aid assessments of continued COC trouble areas, indicate migration or degradation rates, and eventually support the FS and Remedial Action Plan (RAP). In addition, soil borings shall be drilled and sampled at identified accessible locations, and the samples analyzed for COCs.

Additional data will be collected on vertical extent of vadose-zone contamination and probable vertical pathways. Solubility-coefficient data and soil properties will be needed to understand vertical migration and estimate impacts from vadose contamination on the groundwater system.

Several known former seepage pits have been determined to lie along or just within the footprint of newly constructed buildings. The foundation and construction drawings for these new structures have been reviewed to ascertain whether or not soil borings can be drilled at these locations. Where seepage-pit locations are inaccessible for soil-borings, the seepage-pit locations will be assessed by the placement of nearby soil vapor sampling probes and downgradient groundwater monitoring wells.

A summary of data requirements for further potential source identification and source characterization are the following:

- Soil-vapor data from known and suspected source areas.
- Soil sample analysis data distributed horizontally and vertically from known and suspected source areas and hot spots.
- Soil-vapor data from vapor wells in known source areas and hot spots.
- When necessary, continue to research other categories of construction drawings in the microfiche files (e.g., demolition plans, buried utilities, grading plans, etc.).

- Examine "hard-copy" drawing files for available data (where microfiche are not available) on sewer system installations, storm drains, foundation, and grading plans for newer buildings constructed at former building sites.

6.2.2 Contaminant-Source Characterization

The proposed RI activities for the contaminant-source characterization at JPL are summarized in this section. Discussions addressing the proposed field activities, sample analyses, and the report format are presented here. Complete details concerning the investigation will be included in the FSAP prepared for OU-2.

The contaminant-source component of the RI focuses on defining the location and the extent to which each location may have or is presently contributing to the contaminants detected in the groundwater. Because of surficial changes, such as building demolition and construction, erosion, excavation, etc., in areas on JPL where waste disposal may have occurred in the past, and uncertainties about precise disposal locations, a number of sampling methods will be necessary to achieve the program goals.

The program to identify and characterize each potential contaminant source area will begin with a shallow soil-vapor survey. Initially, soil-vapor samples will be collected at proposed locations shown in Figure 6-1. A mobile soil vapor sampling van will be used to collect one soil-vapor sample at each location from a depth of 20 feet, or shallower if refusal occurs. Attempts will be made to locate the mobile sampling van as close to the potential source location as possible. If the potential source location cannot be accessed by the mobile sampling van, then the soil vapor sampling probe will be driven into the subsurface soil manually with a sliding hammer-drive apparatus or by using either a pneumatically or hydraulically driven jack hammer. In some instances, holes will be drilled through concrete flooring to allow soil-vapor sampling. In all cases, soil-vapor samples will be obtained as close as possible to the identified potential source location. Because of inaccuracies inherent with transferring dimensions from microfiche enlargements at differing scales, the potential source location plotted on recent facility maps are believed to have a margin of error ranging from ± 5 to ± 10 feet. The locations for the seepage pits will be marked in the field by measuring from established reference points on the site.

The soil vapor samples will be analyzed for VOCs using EPA Methods 8010/8020. The sampling and analyses procedures will follow those outlined in the RWQCB's requirements for active soil gas investigations. Locations where 1 milligram per liter (mg/l) total volatile organic compounds or greater are detected will be further investigated with at least one additional round of shallow soil-vapor sampling.

The second round of sampling will consist of additional soil-vapor samples collected from a minimum of three locations approximately 10 to 20 feet from the initial location forming a triangle centered over the original location. This second round of soil-vapor sampling will proceed only after underground utilities are located and surface obstructions are identified. The final locations of the additional soil-vapor samples may be greatly influenced by surrounding buildings and underground utilities.

Data from potential source areas where additional soil-vapor samples are collected will be evaluated to determine if the elevated VOC contaminant locations are adequately located for the installation of soil vapor monitoring wells. If a VOC contaminant source location is suspected to be present, but is still not adequately located after the first round of additional soil-vapor sampling, another round of shallow soil-vapor samples will be collected.

Soil-vapor monitoring wells will be installed to 100 feet below grade or less, depending on the depth to the groundwater table, at locations where elevated VOCs were identified. It is anticipated that a cluster of small diameter casings will be installed with individual screen sections located approximately every 20 feet down to 100 feet. The final number and depths of soil vapor sampling devices installed in each monitoring well will be dependent on soil staining, odors, stratigraphy of the soil column, and instrument readings of VOC concentrations encountered during drilling. Soil-vapor samples from each screened interval will be collected and analyzed for VOCs (EPA Methods 8010/8020) soon after the wells are installed and on a pre-approved schedule thereafter for one year to evaluate potential source areas which may impact groundwater, determine variation and extent of soil contaminants, establish the vapor distribution to be used in the potential design of vapor-extraction system (VES) and to aid in determining the potential efficiency and design for any cleanup actions, including VES.

To evaluate non-volatile contaminants of concern in the soil at JPL, soil samples will be collected at each accessible potential contaminant-source area and analyzed for Title 26 metals with hexavalent chromium (plus strontium), cyanide, nitrate, SVOCs, and TPH. Soil samples will also be analyzed for VOCs if collected from potential source locations where soil-vapor samples have indicated their presence. The soil borings will be drilled and sampled to an approximate depth of 50 to 100 feet below grade with a percussion hammer drill rig using a dual-wall drive pipe and reverse-air circulation. Soil samples will be collected for laboratory analysis at 10-foot intervals beginning at a depth of 10 feet. The final sampled intervals of each boring may be altered depending on field observations and instrument measurements. Soil samples will be collected with a split-spoon sampler following procedures outlined in the FSAP for OU-2.

Lithologic descriptions of the soil cuttings and soil samples will be made using the Unified Soil Classification System and recorded on field boring log forms. After all of the samples have been collected from a particular boring, that boring will be backfilled with bentonite chips to the ground surface and abandoned. All potentially contaminated materials generated during the field investigation, including soil cuttings, will be collected and stored. During drilling activities, the soil cuttings will be placed and stored in roll-off bins. The analytical results from the soil samples collected will be used to determine the proper method of disposal pursuant to applicable EPA guidance on investigation-derived wastes (EPA, 1991 and 1992a). Should analyses show the soil cuttings are hazardous, disposal at an approved, licensed off-site facility will be arranged.

Equipment decontamination procedures for all subsurface soil drilling and sampling equipment, and sample labeling, packaging, and chain-of-custody procedures are presented in the FSAP prepared for OU-2.

A field quality assurance (QA) program will also be enacted to evaluate the precision of the laboratory analyses, the effectiveness of decontaminating the sampling equipment, and sample handling procedures. Collection of duplicate samples and equipment blanks will be included in this program (see OU-2 FSAP).

After the field activities are completed, all data will be compiled and evaluated. Concentrations of contaminants in the subsurface soils will be summarized, delineated and illustrated. Potential on-site VOC sources will be evaluated for their contribution to those compounds identified in the groundwater. Correlations will be made between constituents in the groundwater and potential sources. Impacts, or the potential for impacts, to the aquifer will be evaluated. Data evaluation may identify new data gaps and reveal whether sufficient information and understanding of the site conditions have been obtained to complete the Risk Assessment (RA) and Feasibility Study (FS). Additional site-characterization data may be needed before the RI is completed.

A draft report will be produced to present the analytical data, data evaluations, and conclusions from the RI for OU-2. The general outline for the draft OU-2 RI report is presented in Table 6-4.

6.2.3 OU-2 Source Areas Baseline Risk Assessment

Objectives for the investigation of OU-2 for the BRA include identification of potential COCs, potential source areas and release mechanisms, receptor exposure pathways, and additional data

TABLE 6-4

OUTLINE OF OU-2 REMEDIAL INVESTIGATION REPORT

Executive Summary

- 1. Introduction**
 - 1.1 Purpose of Report**
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 - 1.2.1 Site Description**
 - 1.2.2 Site History**
 - 1.2.3 Previous Investigations**
 - 1.3 Report Organization**
 - 2. Contaminant Source Investigation**
 - 2.1 Soil Gas Investigation**
 - 2.2 Drilling and Soil Sampling**
 - 3. Physical Setting**
 - 3.1 Surface Features**
 - 3.2 Soils**
 - 4. Nature and Extent of Contamination**
 - 4.1 Sources**
 - 4.1.1 Waste Characteristics**
 - 4.1.2 Evidence of Release**
 - 4.1.3 Exposure Potential**
 - 4.2 Soils and Vadose Zone**
 - 5. Contaminant Fate and Transport**
 - 5.1 Contaminant Migration**
 - 6. Baseline Risk Assessment**
 - 6.1 Human Health Evaluation**
 - 6.1.1 Exposure Assessment**
 - 6.1.2 Toxicity Assessment**
 - 6.1.3 Risk Characterization**
 - 6.2 Environmental Evaluation**
 - 7. Summary and Conclusions**
 - 7.1 Summary**
 - 7.1.1 Nature and Extent of Contamination**
 - 7.1.2 Fate and Transport**
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 - 7.2 Conclusions**
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requirements. Each of these OU-2 risk assessment parameters are briefly summarized in the following subsections.

Potential Chemicals of Concern

Since several VOCs have been detected in groundwater which flows under JPL and these VOCs may originate from JPL, some of the site's subsurface soil may demonstrate similar contamination when investigated during the RI/FS. Trihalomethanes detected in OU-1 groundwater are not expected to be found in subsurface soils (Ebasco, 1991). Contaminants that may be detected in subsurface soil for OU-2 include the following:

- Carbon tetrachloride
- Trichloroethene (TCE)
- 1,1-Dichloroethene
- Tetrachloroethene (PCE)
- Toluene
- Xylenes
- Metals

Potential Source Areas and Release Mechanisms

The various waste-disposal areas identified in Section 5.0 of this work plan are possible sources of contamination. Potentially contaminated subsurface soils could release contaminants to groundwater through leaching. Although current data is not sufficient to evaluate this mechanism, subsurface soil leaching to groundwater appears to be the most likely and potentially significant release mechanism for on-site soil.

Three other on-site soil contaminant release mechanisms have been identified, but are not likely to be significant. Release mechanisms for surface soils include wind erosion, surface-water runoff, and volatilization. However, only VOC vapors (see Table 5-21, Section 5.2.1) and low levels of metals have been detected, to date, in soils. Since the area is highly developed and very little exposed surface soil exists on-site, these release mechanisms are not likely to be important. In addition, since the waste pits have been inactive since the 1960s, no VOCs are expected to be detected in on-site surface soils. If subsurface soil is excavated, then VOCs and contaminated particulate soil could be released to the air.

Human Receptors and Exposure Pathways

Human receptors include on-site workers and residents and workers in the vicinity of the site. Exposure pathways to surface soils and potentially exposed subsurface soils include the following:

- Inhalation of volatilized contaminants.
- Dermal contact and soil ingestion and inhalation of airborne metal-contaminated particulate soil.
- Ingestion dermal contact, inhalation of VOCs in groundwater leached from soil.

Human receptors include on-site workers, and off-site adult and child residents. Potential receptors, COCs, and current and future pathways are summarized in Table 6-5.

Ecological Receptors and Exposure Pathways

As stated previously, an ecological site survey will be performed in the RI/FS to determine the requirements for the detailed ecological assessment. A preliminary survey of the ecological receptors and exposure pathways has been performed, the results of which are described below.

At present, the site is partly restricted by a fence to inhibit entry by ecological receptors in higher trophic levels (i.e., larger mammals and reptiles). Although other receptors such as birds, smaller mammals and soil invertebrates may have access to the site.

If the site undergoes excavation in preparation of the proposed DGDMUP (refer to Section 4.1.5), both on- and off-site ecological receptors could be affected by exposed contaminated soils. Vegetative and animal receptors inhabiting the Devil's Gate Reservoir area could be affected by runoff, wind erosion, and volatilization of soil contaminants from soils excavated at the site.

Low levels of metals and total petroleum hydrocarbons were detected in sediment samples taken from the Arroyo Seco stream channel located northeast of the site (see Table 5-10, Section 5.1.9). Although concentrations are low, the ecological risk to sediment biota will be considered (at least qualitatively) in this assessment. Risk to these receptors may increase if on-site subsurface soil is excavated in the future, since exposed contaminated soil could be carried in the runoff into the stream. Detail regarding threatened or endangered species potentially located in the vicinity of the site is discussed in section 4.1.5.

The other additional data requirements for the risk assessment include:

TABLE 6-5

**OU-2 HUMAN RECEPTOR AND EXPOSURE PATHWAYS
ON-SITE SOURCE AREAS**

Receptor	Media	Current Pathway/COCs	Future Pathway/COCs
<u>On-site</u>			
Worker	Surface Soil	Inhalation/VOCs & Metals Dermal Contact/VOCs & Metals Incidental Ingestion/VOCs & Metals	Same as current
	Subsurface Soil	None	(Excavation) Inhalation/VOC & Metals Dermal Contact/VOCs & Metals Incidental Ingestion/VOCs & Metals Ingestion of crops contaminated with particulate soil/metals
<u>Off-Site</u>			
Resident Adult & Child	Subsurface Soil	Inhalation/VOCs & Metals Dermal Contact/VOCs & Metals Incidental Ingestion/VOC's & Metals Ingestion of crops with contaminated particulate soils/metals	Same as current
	Subsurface Soil	None	(Excavation) Inhalation/VOC & Metals Dermal Contact/VOCs & Metals Incidental Ingestion/VOCs & Metals Ingestion of crops contaminated with particulate soil/metals
Ecological Receptors	Surface Soil	None	(Excavation) Soil/Vegetation Ingestion/VOCs & Metals Dermal Contact/VOCs & Metals Inhalation/VOCs & Metals
	Stream Sediment	Soils & Vegetation Ingestion/Metals Dermal Contact/Metals	Same as current

1. Determine the significance of metal concentrations in soils and sediments. For comparative purposes, background soil and sediment concentrations will be determined during the RI/FS by collecting and analyzing samples from an undisturbed location at the JPL site. If a sufficient number is available, conventional statistical procedures (t-test) may be used to compare site soil concentrations to background samples. In the absence of sufficient data, the criteria used to judge whether the concentrations are elevated relative to the background concentrations, will be if the mean site soil concentrations exceed the mean background by a factor of two, or if the maximum site soil concentrations exceeds the mean background concentration by a factor of five.
2. Subsurface soil will be characterized to determine the nature and extent of VOC contamination.
3. The VOC migration patterns from subsurface soil to groundwater will be investigated and modeled.

6.3 OPERABLE UNIT 3 RI FOR OFF-SITE GROUNDWATER

Operable Unit 3 includes the groundwater of the Monk Hill Subbasin that lies directly beyond OU-1. During the scoping meetings for DQO Stage 1, this area was identified as the operable unit with the least amount of characterization conducted. Although off-site, OU-3 contains potential conduits to the human population for migrating contaminants. These conduits include the nearby municipal production wells.

The OU-3 RI will focus on groundwater quality issues only related to JPL releases and also on an understanding of the hydrogeologic boundaries and groundwater flow. Development of the OU-3 RI will support and draw on activities and results from the other operable units. The EPA DQO process of an iterative or staged approach will be adhered to complete this RI section of the entire RI/FS process. The following subsections include discussions on data quality objectives (DQO Stages 1 and 2), site characterization, risk assessment, and sampling strategies (DQO Stage 3) that will be taken to complete the OU-3 RI.

6.3.1 Data Quality Objectives for OU-3

The primary requirements for the off-site groundwater RI involve water quality and groundwater-flow characteristics. Data developed for the OU-3 investigation will be used for characterization, risk assessment, screening and evaluation of remedial alternatives, and remedial design. The data development will support the overall RI DQO process by complementing and combining with the results and decisions made for OU-1 and OU-2 to attain a complete RI/FS and lead on to remedial action. The overall objective of this RI will be to further identify the horizontal and vertical extent of contaminants in the groundwater which are the result of releases at JPL and assess related risks.

Sampling for constituents of interest during the RI for OU-3 will follow EPA Level IV data procedures. Sampling and water-quality data acquisition procedures are discussed in detail in the OU-3 FSAP and the JPL RI/FS QAPP. Data from the initial round of sampling in the RI, and 10 percent of all data subsequently generated, will be evaluated using EPA guidelines as a check on laboratory performance.

Collection and evaluation of water-quality data for OU-3 will be conducted using the RI/FS DQO process. This is an iterative process where data acquired during drilling and construction of new wells and data from monitoring programs will be reassessed throughout the program to ensure that the overall and specific objectives and data gaps are filled. Using the iterative DQO process will allow characterization of the OU-3 to support OU-1 and OU-2 RIs and to help accomplish the goals and schedule of the RI/FS and remedial action programs.

Because of the dynamic groundwater system around the municipal production wells, it will be important to monitor both water levels and water quality routinely throughout the RI from existing and new monitoring wells to determine if changes in water quality occur with time or with pumping of water production wells.

Water-level data from routine measurements in existing and proposed monitoring wells is required to determine the direction of groundwater flow, the effects of pumping from nearby production wells, and the effects of artificial and natural recharge. The water-level data collected using DQO Level I will be used to construct a series of water-level maps when possible in conjunction with OU-1 depicting the change in water-table configuration created by the pumping wells and precipitation events with time. Understanding the changes to the groundwater configuration overtime will aid determination of the location of hydrologic boundaries and their impact to contaminant transport.

Hydraulic-conductivity data will be used to estimate the rate and volume of groundwater flow and contaminant migration rates at the JPL site. Hydraulic conductivities may vary by more than two or three orders of magnitude in non-stratified sediments because of the heterogeneity of the materials. Therefore, delineation of changes in hydraulic conductivity have a direct bearing on solute transport. Additionally, hydraulic conductivity will be a driving factor in numerical modeling efforts to simulate groundwater flow and the effects of pumping. To check the feasibility of different types of remediation, should it become necessary, or to design a pumping system, estimates of the amount of groundwater which would have to be managed are required.

To fully understand the dynamics of the groundwater-flow system and the amount of groundwater which would have to be managed in a remedial-action system, the geometry of the aquifer and a subregional water budget need to be further defined. Knowledge of aquifer geometry will be refined by the proposed drilling. A water budget needs to be developed that encompasses recharge calculated from precipitation less evapotranspiration and runoff losses, and from groundwater sources and sinks, such as the spreading grounds and pumping centers.

The historic pumping rates and any water level measurements from the local production wells will be reviewed to aid in determining the potential aquifer drawdown due to long-term pumping. Future plans and schedules for pumping of the production wells need to be reviewed and incorporated into the verification of a groundwater flow model. Both historic and potential recharge from the Arroyo Seco Canyon and Arroyo Seco spreading grounds will have to be estimated and evaluated as part of a systems approach. Prior to development of this plan, NASA initiated an evaluation of the available relevant groundwater flow and solute transport model codes that would aid in the RI/FS and RD effort. This evaluation (Ebasco, 1992) resulted in the selection of the MODFLOW codes and the companion solute transport code RAND3D. These were selected for use on this project for flow studies, well capture zone evaluations and optimization simulations. Computer modeling will aid in the evaluation of the potential impacts of DGDMUP and the screened remedial alternatives being assessed. The DGDMUP has the potential to dramatically impact the configuration of the groundwater table that surrounds the JPL. As the DGDMUP takes shape it may be necessary to model these potential impacts prior to selection of the final remedial alternatives and will be needed during the RD phase.

Data requirements for the groundwater investigation include the following:

- Water-quality samples from existing monitoring wells, analyzed by a state-certified laboratory according to EPA guidelines;
- Water-quality samples collected after installation of proposed monitoring wells;
- Historic water-level and quality data from nearby production wells;
- Water-level data from existing and proposed monitoring wells, measured to the nearest 0.01 ft;
- Aquifer coefficients of hydraulic conductivity and storativity from deep MP wells, from previously conducted tests of production wells, and from an aquifer test, if additional data is required;
- Historic and future pumping rates from local production wells;
- Historic climatological data on precipitation;
- Sub-regional streamflow and runoff data; and
- Physical soil properties of aquifer material.

6.3.2 Off-Site Groundwater Characterization

Presented in this section is a summary of the proposed Remedial Investigation (RI) activities for the off-site groundwater characterization at JPL. Discussions addressing the proposed field activities, sample analyses, data evaluation, and the RI report format are presented here. Complete details concerning the investigation are included in the FSAP prepared for OU-3.

The off-site groundwater component of the RI focuses on determining where contaminants may occur, the vertical and horizontal extent of contaminants, and the configuration of the water table. Five new well locations are proposed based on information from previous investigations, including groundwater, site hydrogeology, and history of pumping practices. The locations of proposed wells are presented in Figure 6-12. The five proposed well locations have been selected to enhance understanding of areas where specific information is lacking.

The rationale for selecting each proposed new off-site monitoring well location was primarily based on specific goals of the RI. Below is a summary of the rationale for the location of each new well.

- Well MW- 17, a proposed deep multi-port monitoring well (see OU-3 FSAP), will be located midway between the municipal supply wells on Pasadena and Lincoln Avenues. It will be located 700 feet east of the Arroyo Seco Spreading Grounds and OU-1/OU-3 boundary and 2,200 feet southeast of JPL (Figure 6-12). When completed, MW-17, will be used to monitor contaminant movement downgradient from the JPL site. As a deep multi-port completion, the well will also provide information on the vertical contaminant distribution. MW-17 will be a control point for potentiometric-surface surveys which will be used to define the dynamic groundwater system in the vicinity of the municipal supply wells.
- Well MW-18, a proposed deep multi-port monitoring well (see OU-3 FSAP) will be located 500 feet east of the OU-1/OU-3 boundary and 1,300 feet east of the JPL (Figure 6-12). When completed, MW-18, will be used to monitor contaminant movement downgradient from the JPL site if groundwater flow places the well in this position. As a deep multi-port completion, the well will also provide information on the vertical contaminant distribution. MW-18 will also be a control point for potentiometric-surface surveys which will be used to define the dynamic groundwater system in the vicinity of municipal supply wells and the Arroyo Seco Spreading Grounds.
- Well MW-19, a proposed deep multi-port monitoring well (see OU-3 FSAP) will be located 4,000 feet southeast of JPL, west of the Devils Gate Reservoir and 600 feet due south of Five Acres School (Figure 6-12). When completed, MW-19 will evaluate contaminant migration toward the Los Flores Water Company wells and will be a downgradient monitor for the JPL site. As a deep multi-port completion the well will also provide information on the vertical contaminant distribution. Well MW-19, will also be a control point for potentiometric-surface surveys which will

be used to define the dynamic groundwater system between the City of Pasadena and Los Flores Water Company municipal production wells.

- Well MW-20, a proposed deep multi-port monitoring well (see OU-3 FSAP) will be located 3,000 feet from the Arroyo Seco Spreading Grounds east on Ventura Street and southeast of the Franklin School. When completed, MW-20, will be used to monitor contaminant movement downgradient from the JPL site. As a deep multi-port completion, the well will also provide information on the vertical contaminant distribution. MW-20 will also be a control point for potentiometric-surface surveys which will be used to define the dynamic groundwater system in the vicinity of municipal well centers.
- Well MW-21, a proposed deep multi-port monitoring well (see OU-3 FSAP) will be located north of the La Canada High School and 2,000 feet southwest of JPL. When completed, Well MW-21, will be used to evaluate groundwater flow into the study area from the La Canada/Flintridge area and to provide information on the southern boundary of the groundwater system. As a deep multi-port completion, the well will also provide information on vertical differences in water quality. MW-21 will also be a control point for potentiometric-surface surveys.

Groundwater samples will be collected from all off-site MP monitoring wells during the dry season and wet season of the year pursuant to the restraints of the RI schedule. Groundwater samples will be analyzed for volatile and semi-volatile organic compounds, Title 26 metals with hexavalent chromium (plus strontium), cyanide, and major cations and major anions (Table 6-2). Title 26 metals with hexavalent chromium (plus strontium) and cyanide will be analyzed until it is determined that these constituents are not present in the groundwater over their respective MCLs. The agencies (EPA, RWQCB, and DTSC) will be involved in the decision to stop collecting samples at various wells. The major anion and cation data obtained during periodic groundwater sampling events, coupled with hydrologic observations, will potentially be useful for (1) interpreting groundwater flow patterns and contaminant migration, (2) evaluating the possible effect of surface-water runoff on groundwater quality, (3) evaluating the effect of inorganic constituents on the performance of potential remediation equipment. Samples of soil cuttings will also be collected as part of the installation of the proposed new groundwater wells for evaluating cuttings-disposal options only pursuant to applicable EPA guidance on the disposal of investigation-derived wastes (EPA, 1991 and 1992a) (see FSAP for OU-3). Should analyses show the soil cuttings are hazardous, disposal at an approved, licensed off-site facility will be arranged.

Reports of analytical results from groundwater samples for constituents of interest including volatile and semi-volatile organic compounds, Title 26 metals with hexavalent chromium (plus strontium), and cyanide will include EPA Level IV data packages. Reports of analytical results from the laboratory for general water chemistry analyses (major anions and cations) will be evaluated for data quality and presented with EPA Level III data packages. All data obtained

during the initial RI sampling event, and 10 percent of all samples subsequently collected, will be validated using EPA guidelines as a check on laboratory performance.

A field quality assurance (QA) sampling program will also be enacted to evaluate the precision of the laboratory analyses, the effectiveness of decontaminating the sampling equipment, and sample-handling and bottle-preparation procedures. Collection of duplicate samples, equipment blanks, field blanks, and trip blanks will be included in this program (see OU-3 FSAP). The proposed analyses to be used on field QA samples are summarized in Table 6-2.

Water-level measurements will be collected from all off-site MP monitoring wells to characterize variations in the water table over time and the direction of groundwater flow beneath OU-3. In the deep multi-port monitoring wells, the piezometric head at each sampling port is measured with a pressure-transducer probe manufactured especially for the unique casing used in these wells.

In addition to monitoring groundwater flow directions and gradients as part of the characterization of the off-site aquifer, rising-head tests will be performed in each deep monitoring well to evacuate the hydraulic conductivity of the aquifer (see FSAP for OU-3). The hydraulic conductivity, along with groundwater gradients, will be used to evaluate groundwater flow rates.

The deep multi-port (MP) monitoring wells have been designed to sample the aquifer at several depths using a single casing. Similar systems have previously been installed on the JPL site using casing components manufactured by Westbay Instruments Ltd. (Ebasco, 1990a). During the OU-3 RI, the five additional deep off-site multi-port wells will be constructed in the same manner using a mud-rotary drilling rig. Details of well drilling and installation procedures for the 4-inch-diameter casing are included in the FSAP for OU-3. A typical design for the deep monitoring wells is shown in Figure 6-11. After the 4-inch casing is installed, each screen interval in the wells will be developed. After this initial development the multi-port casing system will be installed which consists of various components including 1.5-inch-diameter schedule 80 PVC blank casing, PVC couplings used to connect various casing components, PVC measurement-port couplings that facilitate pressure measurements and water sampling, PVC pumping-port couplings that allow well purging or hydraulic-conductivity testing of the aquifer, and nitrile rubber inflatable packers that seal the annulus between screened zones. Once the MP casing has been placed in each well, the nitrile rubber packers between screen intervals will be inflated. After installation, several additional QA/QC checks will be performed. The operation and detailed descriptions of the equipment and procedures used during MP casing installation and procedures for the required QA/QC checks are included in the FSAP for OU-3. After

installation of the MP casing system, each screened interval will be developed further. Each screened interval will be developed by opening the pumping-port valve at that screen and purging water from the screen interval (see FSAP for OU-3). Each screen interval will be considered developed when the pH, turbidity, conductivity and temperature measurements reach stability; and at least three well volumes of the screened interval water has been produced.

At JPL, groundwater samples are currently being collected on a periodic basis from each of the existing monitoring wells. The deep MP wells are sampled with specialized equipment obtained from Westbay Instruments Ltd., the manufacturer. The necessary equipment and procedures for the collection of groundwater samples from the existing and proposed wells are presented in the FSAP for OU-3.

During field activities, existing data and new data will be compiled and evaluated. Concentrations of contaminants in the groundwater will be summarized. Geologic data will be examined and correlated with borehole geophysical surveys to develop soil profiles. Data generated from groundwater monitoring will be interpreted to establish hydraulic gradients and to estimate the flow of groundwater within the aquifer off-site. The nature and extent of contaminants in the groundwater will be delineated and illustrated.

A draft report will be produced to present the analytical data, data evaluations, and conclusions from the RI for OU-3. The general outline for the draft OU-3 RI report is presented in Table 6-6.

6.3.3 OU-3 Off-Site Groundwater Baseline Risk Assessment

Objectives for the investigation of OU-3 for the Baseline Risk Assessment (BRA) include identification of potential COCs potential source areas and release mechanisms, receptor exposure pathways, and additional data requirements. Each of these OU-3 risk-assessment parameters are briefly summarized in the following sections.

Potential Chemicals of Concern

Contaminants detected, to date, in OU-3 groundwater include the following:

- Carbon tetrachloride
- Trichloroethene
- 1,2-Dichloroethane
- Tetrachloroethene (PCE)

TABLE 6-6

OUTLINE OF OU-3 REMEDIAL INVESTIGATION REPORT

-
-
1. Introduction
 - 1.1 Purpose of Report
 - 1.2 Site Background
 - 1.2.1 Site Description
 - 1.2.2 Site History
 - 1.2.3 Previous Investigations
 - 1.3 Report Organization
 2. Off-Site Groundwater Investigation
 - 2.1 Installation of Wells
 - 2.2 Groundwater Sampling Procedures
 3. Physical Setting
 - 3.1 Physiography
 - 3.2 Meteorology
 - 3.3 Geology
 - 3.3.1 Stratigraphy
 - 3.3.2 Structure
 - 3.4 Hydrogeology
 - 3.4.1 Hydraulic Characteristics
 - 3.4.2 Groundwater Flow System
 4. Nature and Extent of Contamination
 - 4.1 Groundwater Quality Analyses
 - 4.1.1 Quality Assurance/Quality Control
 - 4.2 Plume(s) Definition
 5. Contaminant Fate and Transport
 - 5.1 Contaminant Migration
 - 5.1.1 Conceptual Model
 6. Baseline Risk Assessment
 - 6.1 Human Health Evaluation
 - 6.1.1 Exposure Assessment
 - 6.1.2 Toxicity Assessment
 - 6.1.3 Risk Characterization
 - 6.2 Environmental Evaluation
 7. Summary and Conclusions
 - 7.1 Summary
 - 7.1.1 Nature and Extent of Contamination
 - 7.1.2 Fate and Transport
 - 7.1.3 Risk Assessment
 - 7.2 Conclusions
 - 7.2.1 Data Limitations and Recommendations for Further Work
 - 7.2.2 Recommended Remedial Action Objectives
 8. References
-
-

Since there has been more contaminants detected in the groundwater underlying the site, the list of potential COCs for the off-site groundwater may also be expanded to include additional contaminants, such as metals, if they are detected in subsequent investigations. In addition, the same aquifer encompasses both the on-site and off-site groundwater.

Potential Source Areas and Release Mechanisms

The primary source of groundwater contamination appears to be the OU-2 on-site source areas. VOCs may be released from groundwater when public water is used for showering, watering lawns, or washing cars. Both volatilization and infiltration could occur when the water is used outside. Volatilization of VOCs may also occur during showering or bathing.

Human Receptors and Exposure Pathways

A summary of the potential human exposure pathways for the JPL site is presented in this section. Three potentially exposed populations have been identified:

- On-site Workers
- Child Resident
- Adult Resident

All three of these populations may come in contact with the public well water in both the current- and future-use scenarios. The four Pasadena public wells are currently being effectively treated with air stripping and carbon filter remedial techniques; this treatment is monitored. Therefore, current risk of exposure to contaminants in these City of Pasadena public wells may not be a concern. Other water production wells in the vicinity of the JPL site will be evaluated to determine if they are currently being used as a source of water supply. The risk of exposure via these wells may also be evaluated, if necessary.

On-site workers may come in contact with the public well water through dermal contact and ingestion. A less common and significant route of exposure for on-site workers may be inhalation of VOCs in public water that is left standing in reaction or process vessels. The child and adult residents may be exposed to public water by:

- Ingestion
- Dermal contact
- Inhalation during showering or bathing

Potential receptors, COCs, and current and future pathways are summarized in Table 6-7.

TABLE 6-7
OU-3 HUMAN RECEPTOR AND EXPOSURE PATHWAYS
GROUNDWATER EAST OF THE JPL PARKING LOT

Receptor	Current Pathway/COCs	Future Pathway/COCs
ON-SITE		
Worker	Inhalation from standing water/VOCs Ingestion/VOCs Dermal Contact/VOCs	Same as current
OFF-SITE		
Resident Adult & Child	Inhalation during showering/VOCs Ingestion/VOCs Dermal Contact/VOCs	Same as current

Ecological Receptors and Exposure Pathway

Based on existing information, no ecological receptors are expected to come in contact with off-site groundwater. However, upon availability of additional data from the RI, the potential ecological receptors and exposure pathways will be reassessed to assure that all possible exposure scenarios are considered. Currently, minimal exposure may occur during periods in which the aquifer is used for potable water. Release of contaminated water by residents during outside activities such as gardening and landscaping may pose a minor threat to vegetation, domestic animals and common wild animals. These exposure pathways will not be investigated unless it is determined that there is significant contamination of the potable groundwater supply that is not removed prior to entering the water distribution system. Detail regarding threatened or endangered species potentially located in the vicinity of the site is discussed in Section 4.1.5.

Summary of Additional Data Requirements

1. Groundwater in this area should be characterized to determine the nature and extent of VOC contamination.
2. The VOC transport patterns in groundwater in this area should be investigated.
3. Evaluate groundwater quality characteristics, including any seasonal variation, at the point of municipal water well discharge.

7.0 JPL FEASIBILITY STUDY OBJECTIVES

This section discusses feasibility study requirements, as the requirements relate to treatability studies and to regulatory requirements, and applicable or relevant and appropriate requirements (ARARs). The treatability study(ies) for this site, if required, will be media-specific (soils or groundwater) and technology-specific, as discussed below.

7.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

CERCLA, as amended by SARA of 1986, requires the selection of remedial actions at Superfund hazardous waste sites that are protective of human health and the environment, cost-effective, and technologically and administratively feasible. Section 121 of CERCLA specifies that response action must be undertaken in compliance with applicable or relevant and appropriate requirements (ARARs), established in federal and state environmental laws.

The revised National Contingency Plan states that compliance with ARARs is one of the requirements for remedial alternative selection. The revised National Contingency Plan incorporates new requirements that in addition to federal ARARs, remedial alternatives must address state environmental requirements that are more stringent than corresponding federal standards. The other criteria used for identification, screening and development of remedial alternatives are discussed in Section 8.1.9.

In EPA's draft guidance document "CERCLA Compliance with Other Laws Manual" (EPA, 1988), several different types of requirements are identified with which CERCLA remedial actions must comply: (1) chemical-specific requirements; (2) location-specific requirements; and (3) action-specific requirements.

EPA has specified that the different ARARs that may apply to a site and its remediation should be identified and considered at several points in the remediation planning process, as outlined below:

- During preliminary planning for the RI/FS, chemical- and location-specific ARARs may be identified.
- During the site-characterization phase of the RI when the baseline risk evaluation is conducted, the chemical-specific ARARs and location-specific ARARs are identified more comprehensively and used to help determine preliminary cleanup objectives.

It should be noted that once the Record of Decision (ROD) is issued by the lead agency responsible for the site, only the ARARs corresponding to the selected remedial action are considered.

Chemical-Specific ARARs in the Feasibility Study Process

Discussed in this section is a preliminary discussion of chemical-specific ARARs that may apply to remedial actions at JPL. Chemical-specific ARARs assume major significance as each remedial alternative is analyzed with regard to its effectiveness in protecting human health and the environment. The ability to protect human health and the environment is a primary requirement that CERCLA remedial actions must meet. A remedy is considered protective if it "adequately eliminates, reduces, or controls all current and potential risks posed through each exposure pathway [at] the site." In accomplishing this, a given remediation alternative must meet or exceed ARARs or other risk-based levels established through a risk evaluation when ARARs do not exist or are waived.

Chemical-specific ARARs serve two primary uses: (1) to identify requirements that must be met as a minimum by a selected remedial alternative (unless a waiver is obtained) and (2) to provide a basis for establishing appropriate cleanup levels. The public health risk evaluation of a given remedial alternative characterizes the actual risk of exposure of humans to the contaminants of concern.

The requirement that a remedial alternative meet chemical-specific ARARs does not ensure that the alternative is protective, and therefore acceptable. Additional criteria for evaluating acceptability include the following:

- Evaluating the combined risk associated with the ARAR limits for all chemicals at a given site (assuming additivity of effect).
- Establishing that ARARs do not exceed EPA reference doses for noncarcinogenic effects, and are sufficiently protective when various chemicals are present.
- Determining whether environmental effects are adequately addressed by the ARARs.
- Evaluating whether the chemical-specific ARARs adequately cover all significant pathways of human exposure identified in a baseline risk evaluation.

The EPA "Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual" (EPA, 1989a) provides guidance on evaluating exposure to chemicals and on establishing acceptable exposure levels when no chemical-specific ARARs exist.

Identification of Chemical-Specific ARARs for JPL

A list of potential Federal and state chemical-specific ARARs for metals, inorganic compounds, and organic compounds present at JPL will be prepared as part of the RI/FS efforts. The exposure pathway currently of most concern at JPL is through groundwater. The potential chemical-specific ARARs of primary importance are the Federal Water Quality Criteria and the California water quality standards. These are briefly discussed below.

Maximum contaminant levels (MCLs) are enforceable EPA standards and represent the allowable lifetime exposure to a contaminant in public drinking water supplies. The maximum contaminant levels are established taking into consideration potential health effects and incorporate a safety factor to provide adequate protection for sensitive subpopulations. In establishing maximum contaminant levels, EPA also considers the feasibility of attaining such a concentration given the best available technology, treatment techniques, and cost. Present MCLs for JPL COCs are listed on Table 7-1.

As part of the process for developing a final drinking water standard, Maximum Contaminant Level Goals (MCLG) are established at concentrations that are associated with no known or anticipated adverse health effects. Maximum contaminant levels are typically set at concentrations as close to maximum contaminant level goals as is feasible. Present MCLGs for JPL COCs are listed on Table 7-1.

Federal ambient water-quality criteria are guidelines developed by the EPA Office of Water Regulations and Standards for the protection of aquatic life and human health. Although these are not enforceable standards, they represent scientific data and guidance to be used by the states in developing water-quality standards.

State environmental quality standards may be applicable or relevant and appropriate for evaluating remedial actions at waste sites. The availability of, and numerical values for, these standards may vary widely from state to state, and may be more restrictive than federal criteria and standards. The revised National Contingency Plan notes that state standards, requirements, criteria, or limitations qualify for consideration as ARARs only if these have been formally promulgated and consistently applied. California's current drinking-water standards and waste-quality standards are at times more stringent than the Federal standards, and, in those instances, would take precedence over the Federal standards if the standard is an ARAR. California standards for JPL COCs are shown on Table 7-1.

TABLE 7-1
CHEMICAL-SPECIFIC ARARs AT JPL

Chemical of Concern	Groundwater			Soils		
	EPA		DTSC	CCR Title 22		RCRA
	MCL µg/l	MCLG µg/l	MCL µg/l	STLC mg/l	TTLG mg/kg	TCLP mg/l
VOLATILE ORGANIC COMPOUNDS						
Carbon Tetrachloride	5	0	0.5	-	-	0.5
Trichloroethene	5	0	5	204	2,040	0.5
Tetrachloroethene	5	0	5	-	-	0.7
1,1,1-Trichloroethane	200	200	200	-	-	-
1,1-Dichloroethane	-	-	5	-	-	-
1,2-Dichloroethane	5	-	0.5	-	-	0.5
1,1-Dichloroethene	7	7	6	-	-	0.7
cis-1,2-Dichloroethene	70	70	6	-	-	-
Toluene	1,000 ²	1,000	100 ³	-	-	-
Ethylbenzene	700 ⁴	700	680	-	-	-
Styrene	100 ⁵	100	-	-	-	-
Total Trihalomethanes ¹	100	-	-	-	-	6 ⁶
Total Xylenes	10,000 ⁷	10,000	1,750	-	-	-
Freon 113	-	-	1,200	-	-	-
Carbon Disulfide	100 ⁸	-	-	-	-	-
Acetone	100 ⁸	-	-	-	-	-
TOTAL PETROLEUM HYDROCARBONS	-	-	-	-	-	-
METALS						
Arsenic	50	-	50	5	500	5
Barium	2,000	2,000	1,000	100	10,000	100
Beryllium	4	4	-	0.7	75	-
Chromium	100	100	50	560 ⁹	2,500 ⁹	5
Cobalt	-	-	-	80	8,000	-
Copper	1,000 ⁹	1,300	-	25	2,500	-
Lead	15 ¹⁰	0	50	5	1,000	5
Mercury	2	2	2	0.2	20	0.2
Molybdenum	5 ⁸	-	-	350	3,500	-
Nickel	100	100	-	20	2,000	-
Strontium	2,500 ⁸	-	-	-	-	-
Thallium	2	0.5	-	7	700	-
Vanadium	3 ⁸	-	-	24	2,400	-
Zinc	5,000	-	-	250	5,000	-
CYANIDE	200	200	-	-	-	-
HEXAVALENT CHROMIUM	-	-	-	5	500	-
RADIOACTIVITY						
Gross Alpha	15 ¹¹	-	15 ¹¹	-	-	-
Gross Beta	4 ¹²	-	50 ¹¹	-	-	-
SEMI-VOLATILE COMPOUND						
bis(2-ethylhexyl)phthalate	-	-	4	-	-	-

1: Total trihalomethanes include chloroform, dichlorobromomethane, chlorodibromomethane and bromoform.

2: EPA proposed secondary standard is 40 µg/l.

3: California Department of Toxic Substances Control (DTSC) action level.

4: EPA proposed secondary standard is 30 µg/l.

5: EPA proposed secondary standard is 10 µg/l.

6: Chloroform only.

7: EPA proposed secondary standard is 20 µg/l.

8: Non-enforceable health based guidance number.

9: Secondary Maximum Contaminant Level (MCL).

10: Treatment technique and public notification triggered at action level of 15 µg/l.

11: Picocuries per liter.

12: Millirems per year.

Location-Specific ARARs

Several statutes have requirements related to activities occurring in particular locations. For instance, waste management activities in flood plains are restricted under RCRA and critical habitats of endangered or threatened species are protected under the Endangered Species Act. Location-specific ARARs are regulatory requirements or restrictions placed on activities in specific locations that must be met by a given remedial action. These location-specific ARARs are used in conjunction with chemical-specific and action-specific ARARs to ensure that remedial actions are protective of human health and the environment by meeting the requirements of all applicable or relevant and appropriate regulations.

Federal statutes and regulations were reviewed to identify potentially applicable location-specific regulatory requirements that may apply to remedial activities at JPL. Upon preliminary consideration, the JPL site characteristics which are specifically important with respect to ARARs include its location near a flood plain, its location in a seismic region, and the presence of an endangered plant species in the Arroyo Seco. Further evaluation of the location-specific ARARs will be performed as part of the RI/FS. In addition to location-specific regulatory requirements, the State of California has several regulatory requirements that also must be considered as part of this analysis. Many of these regulations are general in nature and do not fall within the criteria set for chemical- or location-specific ARARs.

After reviewing RCRA location requirements for hazardous waste facilities and the requirements of the Endangered Species Act that protect critical habitat, it was determined that these requirements potentially are ARARs for response actions at JPL. Although the requirements relating to the siting of facilities in flood plains may be an ARAR, the requirements relating to seismic hazards are not ARARs because there is no evidence of Holocene fault displacement on JPL or within the entire Sierra Madre fault system east of the San Fernando Valley (Agbabian, 1977). Note that the evaluation of ARARs pertaining to endangered species and seismic hazards are based on a preliminary consideration of these issues and further evaluation is planned as part of the RI/FS.

The ground surface elevations at the JPL site are above the Arroyo Seco flood plain elevation of 1,075 feet (Ebasco 1989), but there is a potential for a 100-year flood to affect the lower parking lot areas of JPL next to the arroyo. The potential for flooding will be evaluated for possible impacts to the remedial alternative selection process.

The plant called Nevin's Barberry, is a Federal Candidate 1 species and State Endangered species that has been observed in the Arroyo Seco Canyon approximately one-half mile downstream

from JPL. If a remedial alternative requires the use of the Arroyo in any way, the Endangered Species Act may be an ARAR for activities in the Arroyo.

Action-Specific ARARs

Action-specific ARARs are performance, design, or other action-specific requirements that apply as a result of a specific technology or activity, or that are limitations on certain actions involving hazardous waste. Action-specific ARARs are identified during the development of remedial alternatives in the Feasibility Study. Specific requirements are triggered by the particular remedial activities within each alternative.

7.2 OPERABLE UNITS 1 AND 3: GROUNDWATER

Groundwater treatability tests may be conducted to assess which of the applicable treatment technologies identified as part of the feasibility study will be most effective in removing or reducing contaminants from groundwater underlying JPL and the surrounding vicinity. The treatment system in place for the City of Pasadena production wells has the capacity to treat large volumes of VOC-contaminated groundwater and may serve as a model for systems installed for JPL. However, alternative technologies may prove more effective and less costly. Accordingly, physical-chemical treatment methods which may be investigated include photolysis.

The treatability study for photolysis of VOC-containing groundwater, if required, will demonstrate:

- Optimum photochemical or mixed photochemical and chemical process for affecting all compounds of concern;
- Impact of sensitive photochemical species present in water on removal efficiency;
- The optimum radiation source absorbed by the target species; and
- The presence of radiation breakdown products resulting from treatment.

During the conduct of the RI and at the beginning of the FS, JPL will evaluate the characterization data collected to identify whether groundwater treatability studies are needed for proper screening of the remedial alternatives. Should a treatability study for either OU-2 or OU-3 be needed, JPL will prepare a brief work plan describing the proposed study to EPA and CalEPA for review.

7.3 OPERABLE UNIT 2: CONTAMINANT SOURCE

Subsurface soil treatability tests may be conducted to assess applicable treatment technologies, and identify, as part of the feasibility study, which technologies will be effective in removing or reducing VOCs contained in source areas at the site. There is information at this time about the nature and extent of subsurface soil containing VOCs at the site, but it is not of sufficient detail to allow the possible alternatives for remediation to be identified. Additional data is needed to analyze whether these source areas are accessible for excavation or if in-situ treatment may be required. Many potential source locations identified to date are located in areas that are inaccessible to heavy machinery. These locations are under buildings or in tightly confined areas between buildings. Because of these constraints, the treatability studies will probably focus on in-situ treatment systems.

The physical-chemical treatment systems that may be investigated include:

- Vitrification,
- In-situ bioremediation, and
- Vapor Extraction.

If conducted, the treatability study for vitrification of VOCs in subsurface would determine:

- Minimum power and temperature requirements,
- Permeability of vitrified material, and
- Quantity and type of admixtures.

If conducted, the treatability study for vapor extraction of VOCs in subsurface soil would demonstrate:

- Removal efficiency of VOCs from soil particles,
- Flow rate of vapors through the soil column, and
- Above ground treatment systems for the vapors.

If conducted, the treatability study for in-situ bioremediation of VOCs in subsurface soil would demonstrate:

- The type of microorganisms required;
- Removal efficiency of microorganisms for various VOCs;

- Optimum moisture, nutrient, and oxygen content of soil required for biore Restoration; and
- Removal efficiency of acclimated versus nonacclimated microorganisms.

During the conduct of the RI and at the beginning of the FS, NASA will carefully evaluate the characterization data collected to identify whether treatability studies are needed for proper screening of the remedial alternatives. Should a treatability study for OU-1 be required, NASA will prepare a brief work plan describing the proposed study to EPA and CalEPA for review.

8.0 RI/FS TASKS

There are 12 tasks that will be accomplished in the completion of the JPL RI/FS. These standard tasks include the following:

- Task 1 - Project Planning**
- Task 2 - Community Relations**
- Task 3 - Field Investigation**
- Task 4 - Sample Analysis and Validation**
- Task 5 - Data Evaluation**
- Task 6 - Risk Assessment**
- Task 7 - Treatability Study and Pilot Testing**
- Task 8 - Remedial Investigation Reports**
- Task 9 - Remedial Alternatives Development/Screening**
- Task 10 - Detailed Analysis of Alternatives**
- Task 11 - Feasibility Study Reports**
- Task 12 - Post RI/FS Support**

8.1 SUMMARY OF TASKS

Descriptions of each task to be completed during the JPL RI/FS are described briefly in the following subsections.

8.1.1 Project Planning (Task 1)

Planning for the Remedial Investigation/Feasibility Study (RI/FS) consists of the preparation of this RI/FS Work Plan, the Quality Assurance Project Plan (QAPP), the site-specific Health and Safety Plan (HASP), the OU-specific Field Sampling Analysis Plans (FSAPs) and the Community Relations Plan (CRP).

Contents of the QAPP, HASP, FSAP, and CRP can be summarized as follows:

- **QAPP:** Includes a description of project organization, Quality Assurance Objectives, sampling procedures, sample custody, analytical procedures, data handling, quality control, audits, preventative maintenance, data assessment, corrective actions, and various QA documentation.
- **HASP:** Includes site information, a hazard evaluation, training requirements, monitoring procedures for site operations, safety considerations during site operations, and decontamination and disposal procedures.

- **FSAP:** Documents sampling objectives; locations and frequency; sample designation; sampling equipment and procedures; and sample handling and analyses.
- **CRP:** Documents community relations history; documents issues of community concern; and describes techniques needed to inform and involve the community regarding the CERCLA effort at JPL.

8.1.2 Community Relations (Task 2)

The NASA community relations program will be a site-specific and integral component of the overall RI/FS process. The NASA community relations effort will include activities to promote two-way communication between NASA and the local community. These activities will also ensure that the local community receives accurate and timely information about site investigation and clean-up efforts and that local concerns and needs are included in all project decision making. The overall goals of the NASA community relations program are as follows:

- Inform the local community of planned or ongoing actions.
- Promote public comment on and input to technical decisions.

Initial activities in NASA's community relations program includes the following:

- Initial Briefing - conducted by NASA designees to identify the goals and requirements of a community relations program and begin planning for the development of NASA's community relations plan.
- Coordination Meeting with EPA - conducted to establish an early working liaison with EPA's community relations coordinator for the JPL site and to ensure that NASA's community relations program conforms with the most current EPA policy and requirements.
- Community Relations Plan (CRP) - NASA will conduct community interviews and develop a site-specific CRP for the JPL site. The draft CRP will be submitted to EPA for approval.

The NASA community relations program will be designed in accordance with all applicable EPA guidelines, as expressed in its *Community Relations in Superfund: A Handbook*, January 1992.

8.1.3 Field Investigation (Task 3)

The field investigation activities will be conducted on an OU-specific basis. The field investigation will include all activities identified in the work plan and FSAP related to sample collection, well installation, and collection of parameters needed to complete the remedial investigation.

8.1.4 Sample Analysis and Validation (Task 4)

The sample analysis and validation task describes the proposed soil, soil-vapor, and groundwater sample analyses and subsequent data-validation efforts. This task includes sample tracking, coordination of laboratory activities, evaluation of data packages, resolution of data-validation issues and completion of data-validation efforts to supply the analytical data required for completion of either the RI or FS. The RI/FS QAPP includes details on all of the relevant guidance, forms, and all procedures related to the data-validation effort.

8.1.5 Data Evaluation (Task 5)

Existing data and data from the field investigation (Task 3) will be compiled and evaluated during this task. Concentrations of contaminant concentrations in the surface and subsurface soils will be summarized. Geologic data will be examined and correlated with borehole geophysical surveys to develop stratigraphic cross-sections. Data generated from groundwater monitoring will be interpreted to establish hydraulic gradients and to estimate the flow of groundwater within the aquifer. The nature and extent of VOCs and other contaminants in the groundwater, soil, and soil vapor will be delineated and illustrated. If sufficient data points are available, concentration contours will be mapped for horizontal distribution of COCs in groundwater, soil, and soil vapor. Groundwater sample analysis results from various well-screen depths will be mapped in cross-section to show vertical distribution of COC's or used to develop plume maps. Soil-sample and soil-vapor data will also be used in cross-sectional views to depict vertical occurrence and extent of COC's detected.

Potential contaminant sources on and off the site will be evaluated for their contribution to those compounds identified in the groundwater. Correlations will be made between constituents in the groundwater and potential sources. Impacts, or the potential for impacts, to the aquifer will be evaluated.

Data evaluation may identify new data gaps and reveal whether sufficient information and understanding of the site conditions have been obtained to complete the risk assessment (RA) and feasibility study (FS). Additional site-characterization data may be needed before the RI is completed.

8.1.6 Risk Assessment (Task 6)

A baseline risk assessment will be performed at the completion of the RI data evaluation. The assessment will evaluate potential risks to human health and the environment that could be associated with contamination in Operable Units 1, 2 and 3. The assessment will evaluate

potential risks under current and potential future land-use assumptions in the absence of remedial action beyond that which has already occurred.

The baseline assessment will be conducted using methods consistent with recent EPA guidance on CERCLA risk assessments (EPA, 1989a) and exposure assessment (EPA, 1992b). Chemicals of Concern (COCs) will be identified in surface and subsurface soil and in groundwater, based on the results of the RI sampling activities. COCs selection will be aimed at identifying all contaminants which are likely to pose significant risks to public health and the environment. The specific factors considered during COC selection include the detection frequency, comparisons to the concentrations in background samples, and the toxicologic and environmental fate characteristics of the contaminants.

Exposed populations and exposure pathways will be identified based on information regarding current land uses and receptor behaviors, site reconnaissance results, interviews with site personnel, and planning documents regarding potential future land uses. Some potentially exposed populations and exposure pathways have been identified in other sections of this workplan. All of these populations and pathways will be confirmed, and additional pathways and populations may be added or subtracted, depending upon site-specific information. If there are any "close calls" regarding whether or not a pathway/population should be included in the risk assessment, a screening process described by EPA (EPA, 1988b) will be employed to determine whether it should be included. The general approach to selecting exposure pathways and populations for inclusion will be to include all documented "complete" exposure pathways, as well as those that have a reasonable likelihood of being complete under reasonable assumptions about site land uses and receptor behaviors.

Standard pathway contaminant intake and exposure models (EPA, 1989a) will be used to evaluate health risks from exposures in OUs 1, 2, and 3. Values for exposure parameters (exposure frequency and duration, soil ingestion rates, etc.) will be defined consistent with site-specific information concerning receptor behaviors, EPA guidance on exposure parameter values (EPA 1989a, 1989b, and 1992b), and information from the scientific literature. In keeping with EPA's Guidance on Exposure Assessment (1992b) contaminant exposures and intakes will be evaluated for "high-end" and "mid-range" exposure scenarios. The former scenarios will correspond to a conservative, but reasonable estimate of exposures to the most exposed identifiable individual receptor. This will result in something like an "RME" exposure estimate as currently defined by EPA. Exposure concentrations for the high-end exposed receptor will be estimated as the 95th percentile Upper Confidence Limit on the mean contaminant concentrations, and other exposure parameter variables will be set using conservative assumptions about receptor behaviors associated exposures. The mid-range exposure estimates

will be derived using the arithmetic means of contaminant concentrations and on reasonably-defined assumptions about "typical" receptor behaviors.

The output of the risk assessment will be estimates of incremental lifetime cancer risks and of the potential for adverse noncancer risks, as indicated by noncancer chronic Hazard Quotients and Hazard Indices. Toxicologic dose-response parameter values developed by EPA will be used in the risk characterization. Values will come from the Integrated Risk Information Center (IRIS) database and Health Effects Assessment Summary Tables (HEAST) as required by current EPA policy. Ingestion pathway Cancer Slope Factors (CSFs) and Reference Doses (RFDs) will be used to evaluate risks by all ingestion and dermal contact pathways. Inhalation Unit Risks (URs) and Reference Concentrations (RFCs) will be used in the evaluation of inhalation pathway cancer risks. No extrapolations of dose-response parameters will be made across exposure pathways. Assumptions which are made about the toxicologic properties of specific contaminants will be documented in brief discussions (Profiles) of the individual COCs. Exposure concentrations of contaminants will also be compared to applicable federal and state health-based regulations and guidance.

The risk evaluation results will be presented along with a discussion of the major sources of uncertainty in the risk estimates for the various pathways and populations. The differences between the risk results for the high-end and mid-range risk results for the various populations will provide a quantitative indication of the degree of uncertainty in the risk estimates.

A detailed site reconnaissance and characterization of potential receptors in on- and off-site areas will be performed to assess the potential for ecological exposure to the site contaminants. If it appears that there is the potential for ecological exposures (through the release of contaminated groundwater, for example), then potential exposure concentrations in environmental media may be compared to appropriate environmental standards and benchmark toxicity values. More detailed evaluations (toxicity specific indicator species or food chain modeling) may be performed if qualitative consideration of exposure scenarios indicate that environmental exposure is very likely.

8.1.7 Treatability Study and Pilot Testing (Task 7)

Treatability studies that assess the effectiveness of a technology to reduce the hazards posed by the presence of chemicals in a media may be needed once the remedial alternatives have been identified and screened. The goal of any treatability study is to use either an experimental bench top treatment system or a pilot test to determine whether that system can meet the remedial-design specifications set forth in the risk assessment. Once a list of remedial

alternatives have been identified and screened for both groundwater and subsurface soil, one or more treatment technologies may be evaluated as part of this effort.

Several generic types of treatability studies may be required for subsurface soil containing VOCs including

- Vapor extraction,
- In-situ bioremediation,
- Incineration, and
- Fixation.

For groundwater containing VOCs, the generic type of treatability studies include

- Air stripping,
- Photolysis, and
- Carbon absorption.

If other contaminants of concern are identified, treatability studies may be needed to address their remediation. At this time other significant contaminants are not anticipated to be found and dealt with. The approach to be used to conduct the treatability studies is described in the following section.

8.1.8 Remedial Investigation Report (Task 8)

A remedial investigation report will be produced for each OU to present the analytical data, data evaluations, and conclusions from the RI. These reports will be submitted to the EPA and State of California for review. The general outline for each draft RI report are presented in Section 6.0. The RI report will be prepared after the RI field activities, and after the sample analysis and validation and data evaluation tasks have been completed and before completion of the draft FS report.

8.1.9 Remedial Alternatives Development and Screening of Remedial Alternatives (Task 9)

The feasibility study (FS) development and screening of remedial alternatives for contaminants in on-site and off-site groundwater and subsurface soil associated with JPL will consist of two phases. In the initial phase of the FS, a preliminary list of remedial alternatives for both media of concern will be identified and screened for effectiveness in protecting human health and the environment. Phase two of the FS (Task 10) will involve a detailed analysis of each alternative

based on the nine basic criteria used to evaluate remedial alternatives to reduce contaminant concentrations to acceptable levels, and prevent exposures to these compounds, or some combination of elimination, reduction, and exposure prevention.

Nine evaluation criteria have been developed to address the CERCLA requirements and considerations listed above as well as additional technical and policy considerations that have proven to be important for selecting among remedial alternatives. These evaluation criteria serve as the basis for conducting the detailed analyses during the FS and for subsequently selecting an appropriate remedial action. The evaluation criteria are divided into three groups.

PRIMARY CRITERIA

- Short-term effectiveness
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Implementability
- Cost

THRESHOLD CRITERIA

- Compliance with ARARs
- Overall protection of human health and the environment

MODIFYING CRITERIA

- State acceptance
- Community acceptance

In developing the remedial alternatives, two issues will be addressed including the identification of volumes or areas of each media to which treatment and containment actions may be applied, possibly in combination with excavation, disposal, or institutional actions. First, the media to be treated or contained will be determined once RI data on the nature and extent of contamination are obtained, ARARs reviewed, and risks associated with no action evaluated. The second issue to be addressed in this phase of the FS will be to identify any newly developed technologies that might be effective for the contaminants and media of concern. The information obtained during these two activities will serve as the basis criteria identified by EPA for selecting remedial alternatives. The results of this detailed analysis of alternatives will serve as a basis for selecting a remedial alternative for each media or operable unit of concern in the Record of Decision.

8.1.10 Detailed Analysis of Alternatives (Task 10)

The last phase of the JPL FS will focus on the final detailed analysis of remedial alternatives for both the groundwater and subsurface soil. During this detailed analysis, each alternative that has been carried forward from the preliminary screening and treatability studies will be assessed against the nine standard evaluation criteria listed above in Section 8.1.9.

The results of this detailed evaluation will be arrayed so that comparisons can be made among alternatives and the key advantages and deficiencies among alternatives can be identified. This approach to evaluating alternatives will be designed to provide sufficient information to adequately compare the alternative technologies, select appropriate remedies, and demonstrate that all statutory requirements are met so that a Record of Decision (ROD) can be drafted.

A detailed analysis of alternatives will consist of the following components:

- Further definition of each alternative, if appropriate, with respect to the volumes or areas of contaminated media to be addressed, the technologies to be used, and any performance requirements associated with those technologies.
- An assessment and a summary of each alternative against the nine evaluation criteria.
- A comparative analysis among the alternatives to assess the relative performance of each alternative with respect to each evaluation criterion.

The detailed analysis provides the means by which facts are assembled and evaluated to develop the rationale for a remedy selection. Thus, the requirements of the remedy selection process ensures that the FS analysis provides the sufficient quantity and quality of information to simplify the transition between the FS report and the actual selection of a remedy. The analysis process described here has been developed on the basis of statutory requirements of CERCLA Section 121; earlier program initiatives promulgated in the November 20, 1985, NCP; the existing "Guidance on Remedial Investigations and Feasibility Studies Under CERCLA," dated May 1985; and site-specific experience gained in the Superfund program. The nine evaluation criteria listed in above in Section 8.1.9 encompass technical, cost, and institutional considerations; compliance with specific statutory requirements; and state and community acceptance.

8.1.11 Feasibility Study Reports (Task 11)

The specific requirements of CERCLA that will be addressed in the ROD and supported by findings of the final FS report include the following:

- The remedy be protective of human health and the environment.
- ARAR's are attained or provide justification for invoking a waiver.
- The technologies and alternative be cost effective.
- That permanent solutions are utilized to the extent possible.
- The technologies selected reduce toxicity, mobility or volume of the affected media.

In addition, CERCLA places an emphasis on evaluating long-term effectiveness and related considerations for each of the alternative remedial actions. These statutory considerations include the following:

- The long-term uncertainties associated with land disposal.
- The goals, objectives, and requirements of the Solid Waste Disposal Act.
- The persistence, toxicity, and mobility of hazardous substances and their constituents, and their ability to bioaccumulate.
- Short- and long-term potential for adverse health effects from human exposure.
- Long-term maintenance costs.
- The potential for future remedial action costs if the alternative remedial action in question were to fail.
- The potential threat to human health and the environment associated with excavation, transportation, and redisposal, or containment.

8.1.12 Post RI/FS Support (Task 12)

After completion of the RI/FS, NASA will prepare the ROD and associated plans with the EPA concurrence.

8.2 MODIFICATION OF WORK PLAN

During the conduct of the RI/FS tasks it may be necessary to modify the proposed work plan as a result of observations made during the field investigation or the treatability study and pilot study efforts. Should it appear that such modifications are necessary, information related to these observations will be presented to EPA, DTSC, and RWQCB for discussion of their impact to the task and overall RI/FS. In the event NASA, EPA, DTSC, and RWQCB agree a work plan modification is necessary, NASA will formally request that modification be made via an addendum to the work plan. This addendum will be submitted to the agencies for review and concurrence. Upon concurrence, the modification activities will be implemented according to an agreed upon schedule. All work shall be completed in accordance with the provisions of the FFA.

8.3 AGENCY COORDINATION

The Federal Facilities Agreement (FFA) establishes a procedural framework for NASA and the three regulatory agencies involved (EPA, DTSC, and RWQCB) to develop, implement, and monitor the RI/FS. The FFA facilitates cooperation, the exchange of information, and the participation of each agency. Each agency has designated a project manager for the purpose of overseeing and implementing the FFA. The project managers are responsible on a daily basis for assuring proper implementation of the RI/FS in accordance with the terms of the FFA. Communications among EPA, DTSC, and the RWQCB on all documents, including reports, comments, and other correspondence, will be directed through the project managers.

The DTSC has been designated the lead regulatory agency for the state pursuant to a Memorandum of Understanding (MOU) agreed to between the DTSC and the RWQCB dated August 1, 1990. DTSC has the responsibility to ensure that comments from both state agencies are transmitted to EPA, and coordinating the resolution of any disputes between the DTSC and the RWQCB so that the state presents only one position to EPA. In the event one of the agencies institutes new regulations, the other agencies will be notified if the changes affect the project in any way.

The Agency for Toxic Substances and Disease Registry (ATSDR) is part of the U.S. Public Health Service under the Department of Health and Human Services. ATSDR is an independent Federal agency that was created in 1980 by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), or Superfund. ATSDR is a non-regulatory agency charged with preventing or mitigating adverse human health effects resulting from exposures to hazardous substances, by providing Public Health Assessments for all sites on or proposed for the National Priorities List (NPL). ATSDR will therefore be performing a Public Health Assessment on JPL.

An ATSDR Public Health Assessment reviews three primary sources of information to determine if exposures to hazardous substances might have posed or currently pose a risk to humans. These sources are: (1) environmental data on contaminants and exposure pathways; (2) health data, which may include available information on community-wide rates of illnesses, diseases, and death rates compared with national or state rates; (3) community concerns. This data is collected from the EPA, state and local environmental and health agencies, the community (through meetings with organized groups and individuals), as well as potentially responsible parties.

The ATSDR Public Health Assessment will provide a description of the potential risks to human health, and make recommendations to protect the public from further exposures, as indicated.

These recommendations may include identification of long-term health studies; or include referrals for other follow-up health actions to be taken by the appropriate federal, state, or local agencies. Finally, the Public Health Assessment process typically takes several years to complete, from the initial scoping visit through the generation of the draft documents, a series of regulatory and community reviews, to the final product.

Notification

Pursuant to the requirements outlined in the FFA concerning notification, NASA, EPA, RWQCB, and DTSC will transmit all documents, and associated comments, and all related notices as required by the FFA by next day mail, hand delivery, or facsimile. All time limitations as included in the FFA will commence upon receipt. All routine correspondence for the RI/FS will be sent via first class mail.

9.0 COST AND KEY ASSUMPTIONS

The estimated costs for completing all activities through the final Record of Decision (ROD) along with costs associated with expedited remedial response measures such as the City of Pasadena's groundwater treatment plant operation are approximately \$7,700,000.

The primary assumptions used in preparing this cost estimate are the following:

- Drilling activities are not adversely impacted by difficult drilling conditions over and above what is already anticipated.
- Off-site well control information can be obtained from existing production wells.
- Soil vapor probe investigations are not adversely impacted by field conditions over and above what is already anticipated or dynamic program shifts in emphasis.
- Field activities are not delayed because of availability of specialized drilling equipment or adverse weather conditions.
- Limited, if any, treatability studies are required to complete the FS.

10.0 SCHEDULE

The Project Schedule for completing the RI/FS and RODs for each of the three operable units is presented in Table 10-1. The schedule and list of deliverables to be presented to USEPA and CalEPA are also given in this figure.

The draft project-wide deliverables that set forth the technical approach (RI/FS Work Plan), the method of assuring project quality (Quality Assurance Project Plan), and approach to incorporating community involvement (Community Relations Plan) will be revised incorporating agency (EPA, DTSC, and RWQCB) comments. The Quality Assurance Project Plan (QAPP) and the Community Relation Plan (CRP) were resubmitted for review on September 24, 1993. The date for resubmission of the RI/FS Work Plan was extended to October 24, 1993. If all comments have been adequately addressed, the documents will go Final in 30 days unless a shorter time span is agreed upon. The three documents that will serve to outline the technical program with the specific details of field-related activities, the OU-specific Field Sampling Analysis Plans (FSAPs) will undergo similar review cycles.

The RI field work phase of this program is very aggressive given the extremely difficult field drilling conditions inherent to the JPL site. During the field program if the potential of difficult drilling conditions appear to be affecting the program schedule it is anticipated that additional drilling rigs will be ready and called on to recover lost time or prevent slippage of the project schedule. A number of significant assumptions are built into the schedule for each operable unit. These assumptions include the following:

- Drilling refusal problems and significant rig downtime is minimal.
- Soil vapor probe studies are not impacted due to site conditions.
- Unusual weather events that present unsuitable safety conditions do not occur.
- Off-site drilling location access agreements are obtained in a timely fashion.
- On-site drilling or vapor-probe surveys are not impacted by conduct of internationally significant lab studies.

Documentation of the RI field work, the laboratory data derived from the samples collected, and results of data validation will be incorporated into the RI report. The RI report will contain all analytical results, site physical characteristics, nature and extent of contamination, conceptual model of contaminant fate and transport, the baseline risk assessment, and conclusions relevant to developing the FS report.

TABLE 10-1

JPL - FINAL RI/FS SCHEDULE

Activity ID	Activity Description	Start	Finish
PROJECT WIDE DOCUMENTS			
00100A	RI/FS Workplan to EPA	1Mar93	7Jun93
00100B	QAPP to EPA	1Mar93	7Jun93
00100C	Community Relations to EPA	1Mar93	7Jun93
00100D	EPA Review Draft RI/FS Workplan	7Jun93	6Aug93
00100E	EPA Review Draft GAPP	7Jun93	6Aug93
00100F	EPA Review Draft Community Relations Plan	7Jun93	6Aug93
00100G	RI/FS Workplan Finalized	6Aug93	24Oct93
00100H	QAPP Finalized	6Aug93	24Sep93
00100I	Community Relations Plan Finalized	6Aug93	24Sep93
OU-1 ON-SITE GROUNDWATER			
00101A	OU-1 FSAP to EPA	1Mar93	7Jun93
00101B	EPA Review OU-1 FSAP	7Jun93	6Aug93
00101C	Groundwater Modeling	7Jun93	20Apr94
00101D	OU-1 FSAP Finalized	6Aug93	24Sep93
00101E	RI Fieldwork	24Sep93	20Jun94
00101F	Lab Data Validation	22Jun94	26Jun94
00101G	Prepare RI Report	22Jun94	29Sep94
00101H	Prepare FS Report/Proposed Plan	27Jul94	5Dec94
00101I	EPA Review RI Report	29Sep94	28Nov94
00101J	RI Report Finalized	28Nov94	23Jan95
00101K	EPA Review FS Report/Proposed Plan	5Dec94	3Feb95
00101L	FS Report/Proposed Plan Finalized	3Feb95	31Mar95
00101M	Public Comment on Proposed Plan	31Mar95	1May95
00101N	Rod Prepared	27Apr95	15Jun95
00101O	EPA Review Rod	15Jun95	14Aug95
00101P	Rod Finalized	14 Aug 95	13 Oct95
OU-2 ON-SITE SOURCE IDENTIFICATION			
00102A	OU-2 FSAP to EPA	29Mar93	7Jul93
00102B	EPA Review OU-2 FSAP	7Jul93	6Sep93
00102C	OU-2 FSAP Finalized	6Sep93	26Oct93
00102D	RI Fieldwork	27Oct93	23Sep94
00102F	Prepare RI Report	26Aug94	30Nov94
00102E	Lab Data Validation	24Sep94	31Oct94

TABLE 10-1

(Continued)

Activity ID	Activity Description	Start	Finish
00102I	Prepare FS Report/Proposed Plan	30Oct94	10Feb95
00102G	EPA Review RI Report	30Nov94	30Jan95
00102H	RI Report Finalized	30Jan95	27Mar95
00102J	EPA Review FS Report/Proposed Plan	10Feb95	11Apr95
00102K	FS Report/Proposed Plan Finalized	11Apr95	6Jun95
00102L	Public Comment on Proposed Plan	6Jun95	6Jul95
00102M	Rod Prepared	19Jun95	8Aug95
00102N	EPA Review Rod	8Aug95	9Oct95
00102O	Rod Finalized	9Oct95	8Dec95
OU-3 OFF-SITE GROUNDWATER			
00103A	OU-3 FSAP to EPA	2Aug93	29Oct93
00103B	EPA Review OU-3 FSAP	29Oct93	28Dec93
00103C	OU-3 FSAP Finalized	28Dec93	28Feb94
00103D	RI Fieldwork	2Mar94	13Feb95
00103E	Groundwater Modeling	6Jul94	12Jan95
00103J	Prepare FS Report/Proposed Plan	24Jan95	31May95
00103F	Lab Data Validation	14Feb95	20Mar95
00103G	Prepare RI Report	22Feb95	22May95
00103H	EPA Review RI Report	22May95	21Jul95
00103K	EPA Review FS Report/Proposed Plan	31May95	31Jul95
00103K	RI Report Finalized	21Jul95	19Sep95
00103L	FS Report/Proposed Plan Finalized	31Jul95	29Sep95
00103M	Public Comment on Proposed Plan	29Sep95	30Oct95
00103N	Prepare Rod	30Oct95	19Dec95
00103O	EPA Review Rod	19Dec95	18Jan95
00103P	Rod Finalized	18Jan96	18Mar96

The FS report, in which evaluations of the remedial alternatives are presented, is another major document to be produced. The proposed schedule has been designed to have the FS activities and report preparation to overlap the RI to a large extent. This approach will expedite the overall schedule. The FS report will include a summary of RI information, identification and screening of technologies, development and screening of alternatives and a detailed analysis of possible alternatives. In addition to the FS report, a plan that describes the alternative selection process and summarizes the technical requirements of the proposed alternative for each OU will be presented. This plan will outline the relevant items necessary to develop the operable unit Record of Decision (ROD) and will go to the public for their concurrence on the remedial alternative. The ROD, when finalized, will serve as the overall directional guidance necessary to develop the OU Remedial Design documents and eventually initiate the Remedial Action activities.

11.0 PROJECT MANAGEMENT

The project organization (Figure 11-1) has been developed to assure that all technical activities are completed in a timely manner and for ease of communications. As set forth in the Federal Facility Agreement under CERCLA Section 120, NASA has agreed to undertake, seek adequate funding for, fully implement, and report on all tasks associated with the site.

NASA has designated a contractor employee to act as the NASA Designated Project Manager (NDPM) until it designates an employee as Project Manager. When NASA designates a NASA employee as Project Manager, the efforts of other contractors and subcontractors noted below will be coordinated by a prime contractor's on-site supervisor who will work directly with the NASA Project Manager. NASA retains all final approvals and authority for tasks implementing the FFA unless it states otherwise. As the NASA Designated Project Manager, the contractor shall make recommendations, including recommendations regarding scope of work, budget, and schedule to NASA officials and obtain NASA's concurrence before proceeding.

To further facilitate completion of this agreement, NASA may designate contractors to assist NASA in the completion of certain aspects of this program. NASA may designate a contractor as a Quality Assurance Officer as required by the FFA. This individual will monitor the implementation of the Quality Assurance Project Plan.

NASA may designate a contractor to supply Public Services support for the implementation of the Community Relations Program. Details of this program may be referred to in the Community Relations Plan. This contractor shall coordinate with the NASA Designated Project Manager.

NASA may designate a contractor Safety Office (SO) to monitor the safe completion of remedial investigation activities according to the procedures outlined in the Health and Safety Plan. This contractor shall coordinate this effort with the NASA Designated Project Manager.

The JPL RI/FS program has been developed on the premise that there are three distinct operable units for evaluation. A separate NASA Authorized Subcontractor Operable Unit Manager (OUM) will be assigned to each unit. The OUM will assist in the development and implementation, with prior approval of the NDPM, all plans and studies required for their respective operable units. Each OUM will work closely with other project personnel on a frequent basis to implement this RI/FS Work Plan. In addition, each OUM will assist in the development of the FSAP for their respective OU and the technical specifications for needed

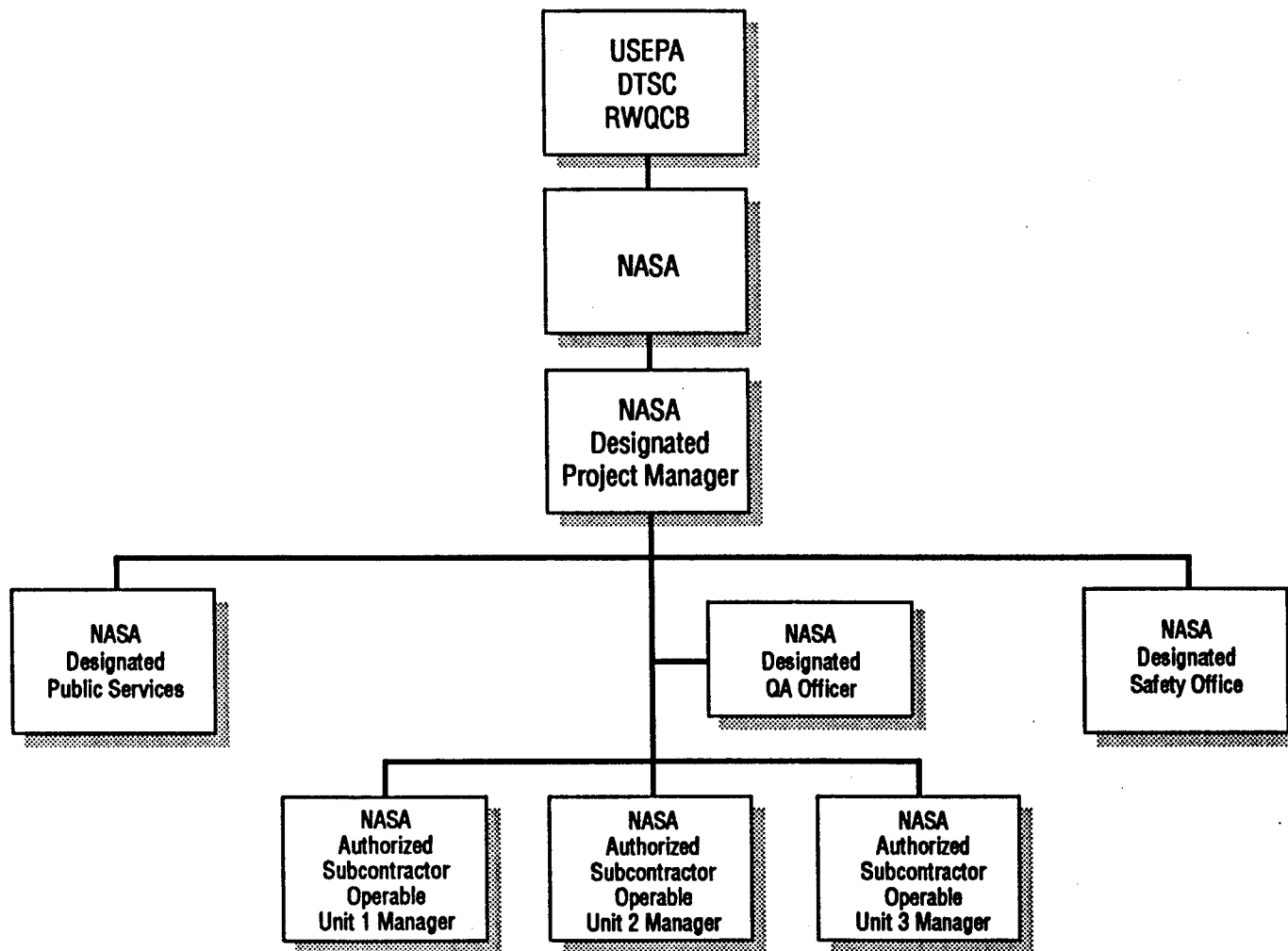


Figure 11 - 1

Summary of Project Organization

subcontracts such as drilling, analytical laboratory services, surveying, and multi-port well equipment installation. These OUMs will procure and schedule all needed services.

The OUMs will also work directly with the NDPM and other project personnel to assure access to all on-site field investigation locations and schedule those activities to minimize disruption of key nationally significant site activities. The OUM will assist in identifying all off-site investigation sites and working closely with the NDPM and other project personnel to negotiate access agreements and schedules for field activities so as to minimize impact on the off-site communities.

The three OUMs will draft the RI and FS reports stipulated in Section 6 of this work plan, assist in the preparation of a response to all comments received on draft documents from EPA and CalEPA, and prepare final versions of those documents for submittal. In addition, the OUMs will provide support for drilling and well installation, soil-vapor investigation, analytical laboratory analyses, surveying, and waste-disposal activities.

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APPENDIX A

SOIL BORING LOGS

EBASCO ENVIRONMENTAL

Soil Boring 1

PROJECT Jet Propulsion Laboratory
 LOCATION Parking lot north of Building 11
 GEOLOGIST Rob Tweidt/B.G. Randolph
 DRILLING CO Layne Environmental
 DATE (start/finish) 10/14/92

DRILLING METHOD Dual-wall air percussion
 SAMPLING METHOD Split spoon, 2.5" X 6" brass sleeves
 SURFACE ELEVATION 1124.4
 TOTAL DEPTH (ft) 100.5
 DEPTH TO WATER (ft) 39.3

Depth (ft)	Well Completion	Sample No.	Samples	OVA (ppm)			Lithology	USCS Symbol	Lithologic Description and Notes
				Drill Pipe	Sample	Breath Zn			
0									ASPHALT - Pavement (3 inches thick).
10		SB1-1-10		0	.5	0			RUBBLE FILL - Mixture of gravelly sand, gravel, and a slag-like material that appears to be fused soil materials, very dark gray-brown, dry to slightly moist, dense. Pieces of red brick at 7'. Same as above, piece of red brick in sampler bit.
20		SB1-2-20		0	.5	0			Pulled drill pipe out of hole; large fragments of red brick observed in borehole wall and at bottom of hole.
30		SB1-3-26		0	0	0		SP	SAND - Silty fine to medium sand with trace gravel, yellow-brown, slightly moist, dense.
				0	-	0		GP	SANDY GRAVEL - Medium to coarse sandy gravel, yellow-brown, slightly moist, dense.
				0	0	0		SP	Cobbles.
				0	0	0		GP	SAND - Fine to medium sand, yellow-brown, slightly moist, dense.
40				0	-	0			SANDY GRAVEL - Medium to coarse sandy gravel with trace fine sand and occasional cobbles, yellow-brown, slightly moist, very dense.
				0	-	0			Sampler wet.
50		SB1-5-50		0	.5	0			Cobbles and boulders 40' to 45', cuttings are wet. Making water with soil cuttings.
				0	1.5	0			Fine to medium sandy gravel with silt.
60		SB1-6-60		0	1.5	0			Fine sandy gravel with some medium sand and trace silt, orange-brown, saturated, very dense.
70		SB1-7-69		0	0	0		SP	SAND - Fine to medium sand with trace gravel, yellow-brown, saturated, dense, micaceous.
80		SB1-8-79.5		0	0	0		SM	SILTY SAND - Silty fine sand with trace coarse sand and fine gravel, yellow-brown, wet, very dense.
				0	0	0		SW	GRAVELLY SAND - Gravelly fine to coarse sand, yellow-brown, saturated, very dense.
90		SB1-9-89.5		0	1	0		SP	SAND - Fine to medium sand, yellow-brown, saturated, dense, micaceous.
				0	0	0			Trace fine gravel.
				0	0	0			Total depth = 100.5' Static water level at 39.3' (1425, 10/14/92)
100		SB1-10-99.5		0	0	0			Fine to medium sand with trace silt.

EBASCO ENVIRONMENTAL

Soil Boring 9

PROJECT Jet Propulsion Laboratory
 LOCATION Parking lot north of Building 280
 GEOLOGIST Rob Tweidt/B.G. Randolph
 DRILLING CO Layne Environmental
 DATE (start/finish) 10/12/92 to 10/13/92

DRILLING METHOD Dual-wall air percussion
 SAMPLING METHOD Split spoon, 2.5" X 6" brass sleeves
 SURFACE ELEVATION 1211.0
 TOTAL DEPTH (ft) 100
 DEPTH TO WATER (ft) Not encountered

Depth (ft)	Well Completion	Sample No.	OVA (ppm)			Lithology	USCS Symbol	Lithologic Description and Notes
			Samples	Drill Pipe	Sample			
0								ASPHALT - Pavement (3 inches thick).
							SP	SAND - Fine to coarse sand with trace silt and some fine gravel, light orange-brown, slightly moist, dense.
10		SB9-1-10		0	0		SM	SILTY SAND - Silty fine to medium sand with trace fine gravel, dark yellow-brown, slightly moist, medium dense.
20		SB9-2-20		0	0			SAND - Silty fine to medium sand.
								Occasional cobbles 24' to 37'.
30		SB9-3-29.5 SB9-3-30		0	0			
40							GP	SANDY GRAVEL - Fine to coarse sandy gravel with occasional cobbles and boulders, yellow-brown, slightly moist to moist, very dense, micaceous.
50		SB9-4-45		0	-	0		Numerous cobbles and small boulders 47' to 57'.
				0	0	0		
60		SB9-6-60		0	0	0	SP	SAND - Medium sand with coarse sand and gravel, yellow-brown, slightly moist, very dense, trace mica. Fine to medium sand with trace silt and fine gravel.
								Gravelly fine to medium sand.
70		SB9-7-70		0	0	0		Occasional thin lenses of cobbles 72' to 77'.
80		SB9-8-80		0	0	0	SM	SILTY SAND - Silty fine to medium sand with trace clay, yellow-brown slightly moist, dense.
90		SB9-9-90		0	0	0		Silty fine sand with trace fine gravel, slightly moist to moist.
								Total depth = 100' No water encountered.
100		SB9-9-100		0	0	0	GP	GRAVELLY SAND - Gravelly fine to medium sand with trace coarse sand, yellow-brown, slightly moist, very dense.

EBASCO ENVIRONMENTAL

Soil Boring 12

PROJECT Jet Propulsion Laboratory
 LOCATION Roadway in front of Building 299
 GEOLOGIST B.G. Randolph/Rob Tweidt
 DRILLING CO Layne Environmental
 DATE (start/finish) 10/18/92

DRILLING METHOD Dual-wall air percussion
 SAMPLING METHOD Split spoon, 2.5" X 6" brass sleeves
 SURFACE ELEVATION 1239.5
 TOTAL DEPTH (ft) 88
 DEPTH TO WATER (ft) Not encountered

Depth (ft)	Well Completion	Sample No.	Samples Drill Pipe	OVA (ppm)		Lithology	USCS Symbol	Lithologic Description and Notes
				Sample	Breath Zn			
0								ASPHALT - Pavement (3 inches thick). Gravel base for pavement.
							GP	SAND (fill) - Fine to coarse sand with some fine gravel and trace silt, orange-brown, slightly moist, medium dense.
10		SB12-1-10		0	0	0	GP	SAND (fill?) - Fine to coarse sand with fine gravel, dark orange-brown, slightly moist, dense.
							GP	SANDY GRAVEL - Fine to coarse sandy gravel with occasional cobbles 10' to 15', light yellow-brown to orange-brown, moist, dense.
20		SB12-2-20		0	0	0	GP	GRAVELLY SAND - Gravelly fine to coarse sand with trace silt, mottled light to dark orange-brown, moist, dense.
								Becoming silty.
30		SB12-3-30		0	0	0		Gravelly fine to coarse sand with silt, orange-brown, very moist, dense.
								Cobbles 34' to 37'. Lens fine to medium sand 37' to 38.5', fine to medium sand, light orange-brown, micaceous.
40		SB12-4-40		0	0	0	GP	SANDY GRAVEL - Fine to coarse sandy gravel with trace silt, orange-brown, moist to very moist, very dense.
								Becoming more silty, more dense.
50		SB12-5-50		0	0	0	SM	SILTY SAND - Silty fine to medium sand with trace coarse sand, orange-brown, moist, very dense.
								Slightly moist.
60		SB12-6-60		0	.2	0		Fine sand with medium sand and trace silt, occasional fine gravel.
								Fine to medium sand with trace silt and fine gravel.
70		SB12-7-70		0	.2	0	SM	SILTY SAND - Silty fine sand with fine gravel, cobbles and trace clay, dark orange-brown, moist, very dense.
								Granite boulder from 72' to 77'.
80		SB12-8-80		0	.2	0	SP	SAND - Fine sand with trace medium sand, orange-brown, slightly moist, very dense.
							SM	SILTY SAND - Highly decomposed granitic boulder, moist, very dense.
		SB12-9-87		0	.2	0	GM	GRAVEL - Silty and sandy gravel with cobbles and boulders, orange-brown, slightly moist to moist, very dense.
90							GP	Decomposed granite and diorite (cobbles and boulders) 82' to 88'.
								Total depth = 88' No water encountered.
100								

EBASCO ENVIRONMENTAL

Soil Boring 19

PROJECT Jet Propulsion Laboratory
 LOCATION Driveway at south end of Building 107
 GEOLOGIST B.G. Randolph/Rob Tweidt
 DRILLING CO Layne Environmental
 DATE (start/finish) 10/16/92

DRILLING METHOD Dual-wall air percussion
 SAMPLING METHOD Split spoon, 2.5" X 6" brass sleeves
 SURFACE ELEVATION 1134.8
 TOTAL DEPTH (ft) 100
 DEPTH TO WATER (ft) 51.0

Depth (ft)	Well Completion	Sample No.	Samples	OVA (ppm)	Drill Pipe	Sample	Breath Zn	Lithology	USCS Symbol	Lithologic Description and Notes
0										ASPHALT - Pavement (3.5 inches thick).
10		SB19-1-10	0	4	0				SM	SILTY SAND (fill) - Silty fine to medium sand with occasional pieces of fine and coarse gravel, dark orange-brown, slightly moist, medium dense. Brick fragments in soil cuttings.
20		SB19-2-18	0	.5	0				SP	Silty fine to medium sand with trace coarse sand, dark brown, moist.
30		SB19-3-30	0	.2	0					SAND - Fine to medium sand with some coarse sand and trace fine gravel, orange-brown, slightly moist, dense. Thin lenses of gravel 20' to 24'. Cobbles from 25' to 27'.
40		SB19-4-38	0	.2	0				GP	Fine to coarse sand with some fine gravel, slightly moist, very dense. Cobbles at 33'. Boulders from 34' to 37'. Fine to medium sand with fine gravel and trace coarse sand, moist.
50		SB19-5-50	0	2	0				GP	SANDY GRAVEL - Fine to coarse sandy gravel with cobbles, light yellow-brown to orange-brown, slightly moist, very dense. Diorite boulder 42.5' to 46'. Gravelly sand.
60		SB19-6-60	0	0	0					Cobbles with some medium to coarse sand, mottled light yellow-brown and black, moist (sample wet). Cobbles and occasional boulder 50' to 58'. Soil cuttings are wet.
70		SB19-7-70	0	0	0				SP	Making water with soil cuttings at 57.5'. Fine gravel with fine to coarse sand, saturated. Boulders up to 3.5' thick 61' to 67.2'.
80		SB19-8-80	0	0	0				GP	SAND - Fine to coarse sand, orange brown, wet, dense, micaceous. Gravelly fine to coarse sand.
90		SB19-9-90	0	.2	0				SP	SILTY SAND - Silty fine to medium sand with some fine gravel, moist to very moist, micaceous.
100			0	-	0				SM	SANDY GRAVEL - Fine to coarse sandy gravel with cobbles and boulders, orange-brown, wet, very dense. SAND - Fine to medium sand, orange-brown, very moist, very dense. Boulder at 81' to 82.5'. GRAVELLY SAND - Fine to coarse sandy gravel with cobbles, orange-brown, saturated. SAND AND SILTY SAND - Alternating thin layers of fine to coarse sand with gravel and silty fine sand, orange-brown, saturated, very dense, micaceous. Boulder at 100'. Total depth = 100'. Static water level at 51.0' (1400, 10/16/92)

EBASCO ENVIRONMENTAL

Soil Boring 21

PROJECT Jet Propulsion Laboratory
 LOCATION Parking lot north of Building 11
 GEOLOGIST Rob Tweidt/B.G. Randolph
 DRILLING CO Layne Environmental
 DATE (start/finish) 10/15/92

DRILLING METHOD Dual-wall air percussion
 SAMPLING METHOD Split spoon, 2.5" X 6" brass sleeves
 SURFACE ELEVATION 1125.5
 TOTAL DEPTH (ft) 101
 DEPTH TO WATER (ft) 40.0

Depth (ft)	Well Completion	Sample No.	Samples	OVA (ppm)			Lithology	USCS Symbol	Lithologic Description and Notes
				Drill Pipe	Sample	Breath Zn			
0									ASPHALT - Pavement (4 inches thick).
								SM	SILTY SAND - Silty fine to medium sand with some fine gravel, dark orange-brown to gray brown, slightly moist, medium dense.
10		SB21-1-10		0	0	0		SW	SAND - Fine to coarse sand with some fine gravel, light orange-brown, slightly moist to moist, medium dense.
				0	-	0		GM	GRAVEL - Gravel and cobbles with fine to coarse sand, light gray to pale brown, dry to slightly moist, very dense.
20		SB21-2-20		0	0	0		SP	SAND - Fine to medium sand with some coarse and some fine gravel, pale brown, slightly moist, very dense, micaceous.
									Boulder from 22' to 25'.
30		SB21-3-30		0	0	0			Fine to coarse sand with silt and gravel.
									Fine to coarse sand with gravel, light to medium orange-brown, slightly moist, very dense.
								GP	SANDY GRAVEL - Fine to coarse sandy gravel with trace silt, light orange-brown, slightly moist, very dense.
40				0	-	0		SP	SAND - Fine to medium sand with some coarse sand and fine gravel, dark orange-brown, wet, dense.
				0	-	0		GP	Sampler wet.
									Light gray color from 42' to 44'.
50				0	1	0			Making water with soil cuttings at 44'.
									SANDY GRAVEL - Sandy fine to coarse gravel with light yellow-brown, orange-brown, and gray, saturated, very dense.
60		SB21-4-60		0	-	0		SP	GRAVELLY SAND - Fine to coarse sand with fine gravel and trace silt, orange-brown, saturated, very dense.
70				0	-	0		GP	SANDY GRAVEL - Fine to coarse sand with gravel, cobbles and boulders, pale yellow-brown to orange-brown, very dense.
									Boulder from 70.5' to 72.5'.
		SB21-5-75		0	0	0		SP GP	GRAVELLY SAND - Fine to coarse sand with fine gravel and trace silt, orange-brown, saturated, very dense.
80		SB21-6-80		0	.5	0		SM	SILTY SAND - Silty fine sand with some medium sand, dark orange-brown, moist, very dense.
									Gravelly from 86' to 88'.
90		SB21-7-90		0	0	0		SP SM	SAND AND SILTY SAND - Alternating thin layers fine to medium sand and silty fine sand with trace coarse sand and fine gravel, orange-brown, saturated, dense.
100		SB21-8-100		0	0	0		SP	Total depth = 101' Static water level at 40.0' (1410, 10/15/92) SAND - Fine sand, dark orange-brown, saturated, very dense, micaceous.

APPENDIX B

BORING LOGS AND WELL COMPLETION/CONSTRUCTION DIAGRAMS FOR JPL MONITORING WELLS

WELL MW-1

BORING LOG AND WELL COMPLETION DIAGRAM

LOG OF DRILL HOLE

JOB NO.: S88042

PROJECT: JPL Upgradient Wells

LOCATION: Pasadena, California

DRILLING METHOD: Rotary Mud, 9 7/8-in.

LOGGED BY: E. Powers

CHECKED BY: C. Kendall

DRILL HOLE NO.: MW-1

DRILLING DATE: August 22, 1989

DATUM: USGS, PP1339, Plate 2.6

REFERENCE EL.: 1115 Feet

ELEVATION (FEET) DEPTH	DRILLING RATE	REAL TIME/DEPTH	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		TORVANE (PSF)	ADDITIONAL TESTS
									LIQUID LIMIT (%)	PLASTIC LIMIT (%)		
1110						"ALLUVIUM (Qal)" SILTY SAND (SM) with cobbles and boulders, light brown, dry, loose.						
10												
1100												
20						set 10" conductor to 15 feet, end of shift 8/22/89.						
1090						"ALLUVIUM (Qal)" SAND (SP) brown with white quartz and feldspar, medium to very coarse grained, angular with traces of clayey silt.						
30												
1080						cobbles.						
40						▽ boulders.						
1070						"ALLUVIUM (Qal)" SILTY CLAY (CL) brown, soft, soluble, with very fine grained sand and lenses of cobbles.						
50						cobbles.						
1060												
60												
1050						"ALLUVIUM (Qal)" SAND (SP) brown, medium to coarse grained, angular with scattered gravel and cobbles.						

LOG OF DRILL HOLE

JOB NO.: S88042

PROJECT: JPL Upgradient Wells

LOCATION: Pasadena, California

DRILLING METHOD: Rotary Mud, 9 7/8-in.

LOGGED BY: E. Powers

CHECKED BY: C. Kendall

DRILL HOLE NO.: MW-1

DRILLING DATE: August 22, 1989

DATUM: USGS, PP1339, Plate 2.6

REFERENCE EL.: 1115 Feet

ELEVATION (FEET) DEPTH	DRILLING RATE	REAL TIME/DEPTH	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		TORVANE (PSF)	ADDITIONAL TESTS
									LIQUID LIMIT (%)	PLASTIC LIMIT (%)		
70						"ALLUVIUM (Qal)" SAND (SP) brown, medium to coarse grained, angular with scattered gravel and cobbles.						
1040												
80						grading to fine to medium grained sand, with lenses of clayey silt.						
1030												
90						becoming coarse to very coarse grained.						
1020												
100						end of shift 8/23/89.						
1010												
110						"ALLUVIUM (Qal)" CLAYEY SAND (SC) brown, very fine to coarse grained, large amount fines as seen in thickening mud, occasional cobbles.						
1000												
120						cobble lens.						
990												
130						traces of weathered feldspar in CLAYEY SAND.						

LOG OF DRILL HOLE

JOB NO.: S88042

PROJECT: JPL Upgradient Wells

LOCATION: Pasadena, California

DRILLING METHOD: Rotary Mud, 9 7/8-in.

LOGGED BY: E. Powers

CHECKED BY: C. Kendall

DRILL HOLE NO.: MW-1

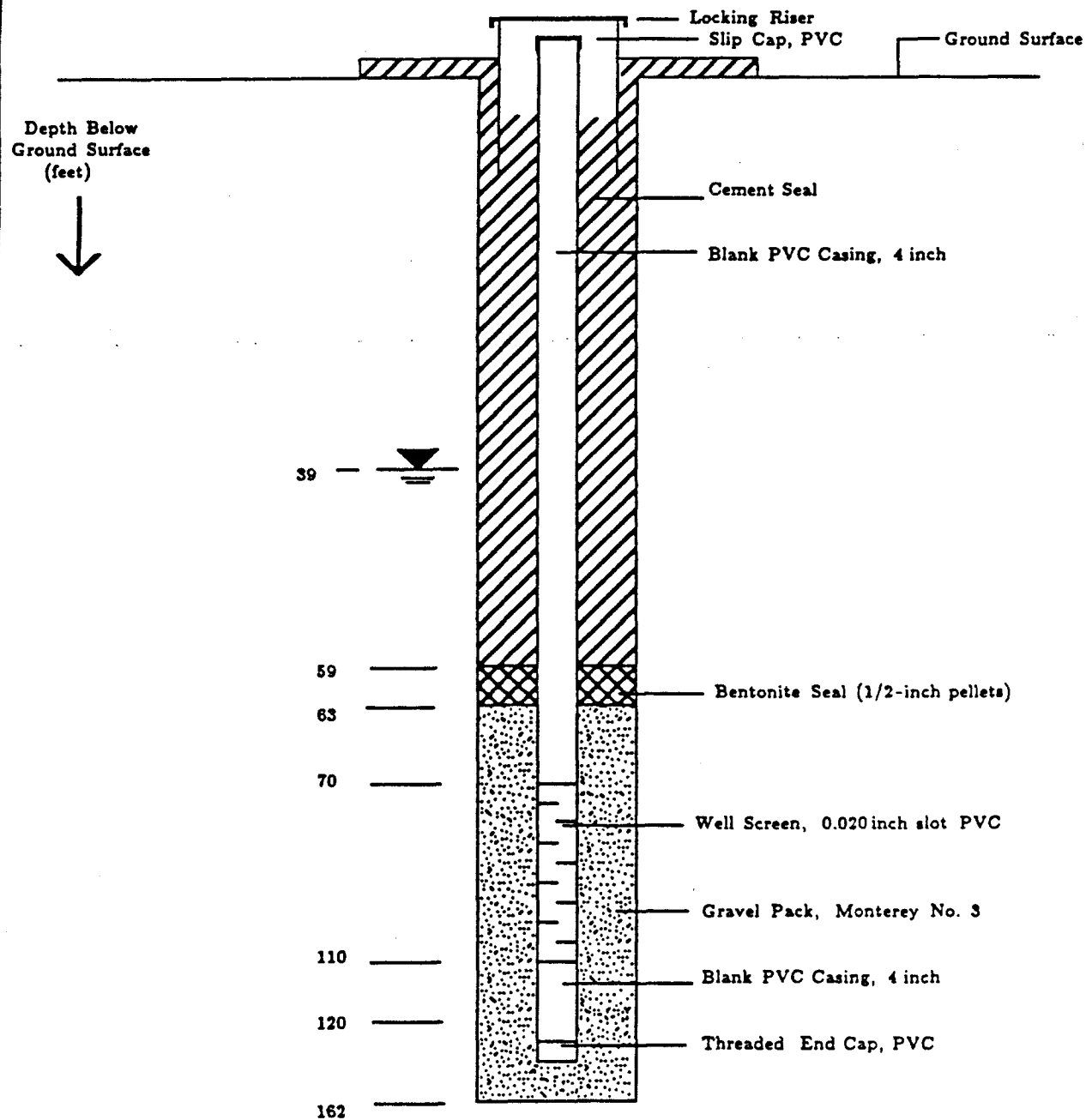
DRILLING DATE: August 22, 1989

DATUM: USGS, PP1339, Plate 2.6

REFERENCE EL.: 1115 Feet

ELEVATION (FEET) DEPTH	DRILLING RATE REAL TIME/DEPTH	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		TORVANE (PSF)	ADDITIONAL TESTS
								LIQUID LIMIT (%)	PLASTIC LIMIT (%)		
980					"ALLUVIUM (Qal)" CLAYEY SAND (SC) brown, very fine to coarse grained, large amount fines as seen in thickening mud, occasional cobbles.						
140											
970											
150					becoming finer grained.						
960											
160					becoming coarser grained.						
					Bottom of drill hole at 162 feet, on 8/24/89. Groundwater estimated at approximate depth of 85 feet based on electric log. Boring completed as Monitoring Well MW-1, water level measured September 5, 1989 at depth of 39.04 feet.						

AS BUILT WELL COMPLETION SCHEMATIC MW-1



WELL MW-2

BORING LOG AND WELL COMPLETION DIAGRAM

LOG OF DRILL HOLE

JOB NO.: S88042

PROJECT: JPL Upgradient Wells

LOCATION: Pasadena, California

DRILLING METHOD: Rotary Mud, 9 7/8-in.

LOGGED BY: E. Powers

CHECKED BY: C. Kendall

DRILL HOLE NO.: MW-2

DRILLING DATE: August 14, 1989

DATUM: USGS, PP1339, Plate 2.6

REFERENCE EL.: 1168 Feet

ELEVATION (FEET) DEPTH	DRILLING RATE REAL TIME/DEPTH	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		TORVANE (PSF)	ADDITIONAL TESTS
								LIQUID LIMIT (%)	PLASTIC LIMIT (%)		
1160					Parking lot pavement, 4" over 8" base. "ALLUVIUM (Qal)" SANDY SILT (ML) light brown, soft, dry, with moderate amount very fine grained sand and scattered rock fragments. becomes damp at 5 feet. cobbles at 8 feet.						
1150					set 10" conductor to 17 feet, end of shift 8/14/89. "ALLUVIUM (Qal)" SAND (SP) multi-colored, predominantly very coarse grained and rounded, with appreciable fines or silt beds. numerous cobbles below 22 feet, primarily granitic fragments, with fine to coarse sand.						
1140											
1130					"ALLUVIUM (Qal)" SAND (SP) multi colored, medium to very coarse grained, with scattered gravel.						
1120					thinned mud, end of shift 8/15/89.						
1110					increasing gravel. numerous cobbles below 61 feet, predominantly granitic with sand. Clear and milky quartz, white and pink feldspar, rare green (metamorphic?), rock fragments, considerable fines as seen in thickening mud.						

LOG OF DRILL HOLE

JOB NO.: S88042

PROJECT: JPL Upgradient Wells

LOCATION: Pasadena, California

DRILLING METHOD: Rotary Mud, 9 7/8-in.

LOGGED BY: E. Powers

CHECKED BY: C. Kendall

DRILL HOLE NO.: MW-2

DRILLING DATE: August 14, 1989

DATUM: USGS, PP1339, Plate 2.6

REFERENCE EL.: 1168 Feet

ELEVATION (FEET) DEPTH	DRILLING RATE	REAL TIME/DEPTH	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		TORVANE (PSF)	ADDITIONAL TESTS
									LIQUID LIMIT (%)	PLASTIC LIMIT (%)		
1100						"ALLUVIUM (Qal)" SAND (SP) with cobbles, multi-colored, medium to very coarse grained.						
70												
1090						"ALLUVIUM (Qal)" SILT (ML) brown, micaceous, slightly clayey, with some very fine grained sand. Below 80 feet, becoming thinly interbedded as noted.						
80						cobbles, primarily granitic rock fragments, with fine-coarse sand and fines.						
1080						silt lenses.						
90						cobbles, as above.						
1070						SILTY SAND (SM) brown, very fine sand with large amount of silt.						
100						CLAYEY SAND (SC) brown, soft, with fine-coarse sand.						
1060						cobbles, granitic rock fragments with fine-coarse sand and silt lenses.						
110												
1050						SILTY SAND (SM) brown, soft, slightly clayey with very fine to medium sand.						
120												
1040												
130												

LOG OF DRILL HOLE

JOB NO.: S88042

PROJECT: JPL Upgradient Wells

LOCATION: Pasadena, California

DRILLING METHOD: Rotary Mud, 9 7/8-in.

LOGGED BY: E. Powers

CHECKED BY: C. Kendall

DRILL HOLE NO.: MW-2

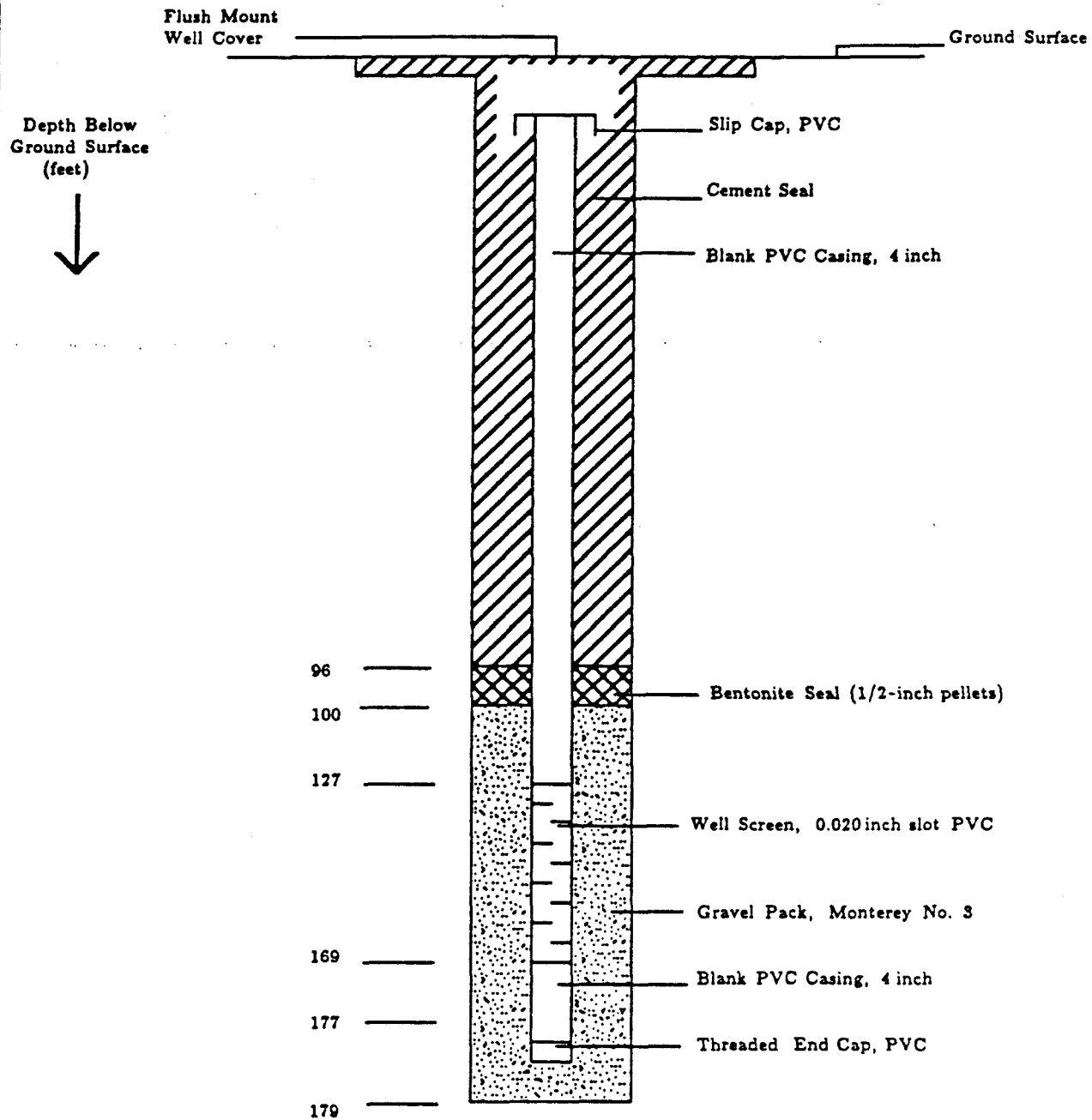
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DATUM: USGS, PP1339, Plate 2.6

REFERENCE EL.: 1168 Feet

ELEVATION (FEET) DEPTH	DRILLING RATE	REAL TIME/DEPTH	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		TORVANE (PSF)	ADDITIONAL TESTS
									LIQUID LIMIT (%)	PLASTIC LIMIT (%)		
1030						Cobbles, primarily granitic rock fragments with traces of dark gray metamorphic (?) fragments, with fine to coarse grained sand and silt. end of shift 8/16/89. SAND (SP) primarily quartz and feldspar, very fine to coarse grained, with some fines.						
140						Cobbles, granitic rock fragments with large amount of very fine to coarse grained sand and soluble clay as seen in thickening mud.						
1020						CLAYEY SAND (SC) brown, fine to coarse grained sand with SILTY CLAY matrix.						
150						Ran E-LOG to 158 feet. SAND (SP) white quartz and feldspar, medium to very coarse grained.						
1010						Cobbles, granitic rock fragments with medium to very coarse grained sand.						
160						SAND (SP) predominantly quartz and feldspar, medium to very coarse grained, with traces of mottled gray brown clay.						
1000												
170												
990												
						Bottom of drill hole at 179 feet, on 8/17/89. Possible groundwater zones below depth 140 feet based on electric log. Boring completed as Monitoring Well MW-2. As of September 5, 1989 no free water has entered the well.						

AS BUILT WELL COMPLETION SCHEMATIC MW-2



WELL MW-3

BORING LOG AND WELL COMPLETION DIAGRAM WESTBAY MP CASING INSTALLATION LOG

EBASCO ENVIRONMENTAL

WELL NO. MW-3

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler, T. Tomczyk
 DRILLING COMPANY Bevlik
 DRILLING METHOD Mud Rotary

DRILL HOLE DIAMETER (in) 15.75/9.875
 GROUND LEVEL ELEVATION (ft) 1100
 TOTAL DEPTH OF HOLE (ft) 730
 DEPTH TO WATER (ft) 130.50
 DATE (start/finish) 1-11-90 to 1-24-90

DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
0		3-1		0	0	N	---		SP	SAND, MULTICOLORED medium to very coarse grained with abundant gravel, predominantly quartz and feldspar. BOULDERS granitic, rounded, up to 2 ft in diam.
10									SP	SAND, MULTICOLORED medium to very coarse grained with abundant gravel, predominantly quartz and feldspar. BOULDER granitic.
20									SP	SAND, MULTICOLORED medium to very coarse grained with abundant gravel, predominantly quartz and feldspar. (drilled 15.75 in. hole to 22 ft.; set conductor pipe; continued drilling with 9.875 in. bit) ("soil-3-1 collected at 9:10 on 1-17-90")
30									ML	
40									SP	SAND, MULTICOLORED medium to very coarse grained with scattered gravel, predominantly quartz and feldspar.
50		3-2		0	0	N	---		SP	SAND, SILTY, LIGHT BROWN moderate amount of very fine grained sand and scattered gravel.
60									SP	SAND, MULTI-COLORED medium to very coarse grained with some gravel, predominantly quartz and feldspar, occasional granitic cobbles. BOULDER
70									SP	SAND, MULTI-COLORED medium to coarse grained with some gravel, subangular to subrounded, few thin lenses of clayey silt.
80									SP	SAND, MULTI-COLORED fine to very coarse grained with abundant gravel, subangular, poorly sorted.
90									SP	SAND, MULTI-COLORED fine to very coarse grained with few granitic cobbles or boulders.
100									SP	BOULDERS SAND, MULTI-COLORED medium to coarse grained, with abundant gravel, predominantly quartz and feldspar. ("soil-3-2" collected at 12:35 on 1-17-90)

EBASCO ENVIRONMENTAL

WELL NO. MW-3

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler, T. Tomczyk
 DRILLING COMPANY Bevlik
 DRILLING METHOD Mud Rotary

DRILL HOLE DIAMETER (in) 15.75/9.875
 GROUND LEVEL ELEVATION (ft) 1100
 TOTAL DEPTH OF HOLE (ft) 730
 DEPTH TO WATER (ft) 130.50
 DATE (start/finish) 1-11-90 to 1-24-90

DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
100				0	0	N			SP	SAND, MULTI-COLORED medium to coarse grained with trace gravel.
110				0	0	N			CL	SAND, MULTI-COLORED medium to coarse grained with trace gravel.
120									SP CL	SILT, CLAYEY, LIGHT BROWN BOULDER
130				0	0	N			SP ML	SAND, MULTI-COLORED medium to coarse grained with common light brown clayey silt to sandy silt (~25%).
140				0	0	N			SC	SAND, BROWN medium to coarse grained with abundant brown clayey to sandy silt. percentage of silt increasing (~50%). (hole angle: 0.125 degrees)
150				0	0	N			SC	SAND, CLAYEY, BROWN very fine to coarse grained, large amount of clay and very fine sand matrix (~70%), occasional granite boulder.
160				0	0	N			SC	SAND, CLAYEY, BROWN very fine to medium grained, large amount of clay and very fine sand matrix, occasional gravel and coarse sand.
170				0	0	N			SC	SAND, CLAYEY, BROWN very fine to coarse grained, trace gravel, becoming coarser grained, silt and clay matrix.
180				0	0	N			SC	BOULDER SAND, CLAYEY, BROWN fine to coarse grained, occasional very coarse sand and gravel, silt and clay matrix.
190				0	0	N			SC	SAND, CLAYEY, BROWN fine to coarse grained, trace gravel, clay and very fine sand matrix (~20%)
200		3-3	X	0	0	N			SC	SAND, CLAYEY, BROWN-MULTI-COLORED fine to coarse grained, clay and silt matrix (~15%) ("soil-3-3" collected at 13:00 on 1-18-90)

EBASCO ENVIRONMENTAL

WELL NO. MW-3

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler, T. Tomczyk
 DRILLING COMPANY Beylik
 DRILLING METHOD Mud Rotary

DRILL HOLE DIAMETER (in) 15.75/9.875
 GROUND LEVEL ELEVATION (ft) 1100
 TOTAL DEPTH OF HOLE (ft) 730
 DEPTH TO WATER (ft) 130.50
 DATE (start/finish) 1-11-90 to 1-24-90

DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
200	<p>LC STEEL CASING</p> <p>304-SS SCREEN 2</p> <p>#2 SAND</p> <p>BENTONITE SEAL</p>			0	0	N	--		SC	SAND, CLAYEY, BROWN very fine to coarse grained, clay and silt matrix (~35%).
210				0	0	N	--		SC	SAND, CLAYEY, BROWN-MULTI-COLORED fine to medium grained, occasional gravel and coarse sand. BOULDER
220				0	0	N	--		SC	SAND, CLAYEY, BROWN very fine to coarse grained, abundant clay and silt matrix (~50%), occasional gravel.
230				0	0	N	--		SC	SAND, CLAYEY, BROWN very fine to coarse grained, clay and silt matrix (~40%).
240				0	0	N	--		SC	SAND, CLAYEY, BROWN very fine to medium grained, cuttings mostly clay and silt (~70%).
250				0	0	N	--		SC	SAND, CLAYEY, BROWN very fine to coarse grained, trace gravel, very abundant clay and silt matrix (~75%). (hole angle: 1 degree)
260				0	0	N	--		SC	SAND, CLAYEY, BROWN very fine to coarse grained, trace gravel, very abundant clay and silt matrix (~65%).
270				0	0	N	--		SC	SAND, CLAYEY, BROWN very fine grained to coarse grained, abundant clayey silt matrix, some silty clay present.
280				0	0	N	--		SC	SAND, CLAYEY, BROWN very fine to medium grained, abundant clay and silt matrix, occasional coarse sand and gravel.
290									SC	SAND, CLAYEY, BROWN very fine to medium grained, abundant clay and silt matrix, occasional coarse sand and gravel.
300		3-4	X	0	0	N	--			SAND, CLAYEY, BROWN very fine to medium grained, abundant clay and silt matrix, occasional coarse sand and gravel. ("soil-3-4" collected at 8:35 on 1-19-90)

EBASCO ENVIRONMENTAL

WELL NO. MW-3

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler, T. Tomczyk
 DRILLING COMPANY Beylik
 DRILLING METHOD Mud Rotary

DRILL HOLE DIAMETER (in) 15.75/9.875
 GROUND LEVEL ELEVATION (ft) 1100
 TOTAL DEPTH OF HOLE (ft) 730
 DEPTH TO WATER (ft) 130.50
 DATE (start/finish) 1-11-90 to 1-24-90

DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
300	LC STEEL CASING 304-SS SCREEN 3 BENTONITE SEAL #2 SAND BENTONITE SEAL			0	0	N			SC	SAND, CLAYEY, BROWN fine to coarse grained, common silt and clay matrix (~45%), occasional boulders.
310				0	0	N			SC	SAND, CLAYEY, BROWN fine to coarse grained, common silt and clay matrix (~45%), occasional boulders.
320				0	0	N			SC	SAND, CLAYEY, BROWN fine to coarse grained, common silt and clay matrix (~45%), occasional boulders and gravel.
330				0	0	N			SC	SAND, CLAYEY, BROWN very fine to coarse grained sand with silty clay matrix (~45%).
340				0	0	N			SC	SAND, CLAYEY, BROWN very fine to coarse grained sand with silty clay matrix (~45%).
350				0	0	N			SC	SAND, CLAYEY, BROWN very fine to coarse grained sand with silty clay matrix (~45%), occasional gravel.
360				0	0	N			SP	BOULDER SAND, CLAYEY, BROWN fine to coarse grained with silty clay matrix (~55%), occasional very coarse sand and gravel.
370				0	0	N			SC	SAND, MULTI-COLORED medium to very coarse grained, minor amounts of brown silty clay, predominantly quartz and feldspar.
380				0	0	N			SP	SAND, CLAYEY, BROWN fine to very coarse grained sand with silty clay matrix (~50%), trace gravel.
390				0	0	N			SC	SAND, MULTI-COLORED medium to very coarse grained, minor brown silty clay, occasional gravel.
400		3-5	X	0	0	N				("soil-3-5" collected at 12:30 on 1-19-90)

DATE (start/finish) 1-11-90 to 1-24-90

EBASCO ENVIRONMENTAL

WELL NO. MW-3

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler, T. Tomczyk
 DRILLING COMPANY Bevlik
 DRILLING METHOD Mud Rotary

DRILL HOLE DIAMETER (in) 15.75/9.875
 GROUND LEVEL ELEVATION (ft) 1100
 TOTAL DEPTH OF HOLE (ft) 730
 DEPTH TO WATER (ft) 130.50
 DATE (start/finish) 1-11-90 to 1-24-90

DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
500	<p>LC STEEL CASING</p> <p>304-SS SCREEN 4</p> <p>#2 SAND</p> <p>BENTONITE SEAL</p>	3-7		0	0	N	--		SC	SAND, MULTI-COLORED trace brown silty clay, trace gravel.
510									SC	SAND, CLAYEY, BROWN medium to coarse grained, silty clay matrix (~60%) BOULDERS
520									SC	SAND, CLAYEY, BROWN fine to coarse grained, silty clay matrix (~25%).
530									ML	SAND, CLAYEY, BROWN fine to coarse grained, silty clay matrix (~50%). (hole angle: 1.125 degrees)
540									ML	SILT, CLAYEY, BROWN silty clay, occasional to common medium to coarse sand present (~10-15%), rare gravel.
550									SC	SILT, CLAYEY, BROWN silty clay, occasional to common medium to coarse sand present (~15%), rare gravel.
560									SP	SAND, CLAYEY, MULTI-COLORED medium to coarse grained, silty clay present (~40%).
570									SP	SAND, MULTI-COLORED medium to coarse grained, predominantly quartz and feldspar, minor silty clay present (~15%). BOULDERS
580									SC	SAND, MULTI-COLORED medium to coarse grained, predominantly quartz and feldspar, silty clay increases to (~20%).
590									SC	SAND, CLAYEY, MULTI-COLORED medium to coarse grained, silty clay matrix (~40%).
600										(*soil-3-7" collected at 11:35 on 1-22-90)

EBASCO ENVIRONMENTAL

WELL NO. MW-3

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler, T. Tomczyk
 DRILLING COMPANY Bevlik
 DRILLING METHOD Mud Rotary

DRILL HOLE DIAMETER (in) 15.75/9.875
 GROUND LEVEL ELEVATION (ft) 1100
 TOTAL DEPTH OF HOLE (ft) 730
 DEPTH TO WATER (ft) 130.50
 DATE (start/finish) 1-11-90 to 1-24-90

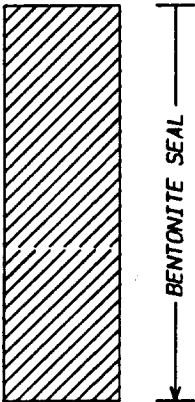




DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	DVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
500				0	0	N	---		SP	SAND, CLAYEY, MULTI-COLORED medium to coarse grained, silty clay matrix (~30%).
610									SP	SAND, MULTI-COLORED medium to coarse grained, silty clay matrix (~15%).
620									SC	SAND, MULTI-COLORED medium to coarse grained, silty clay matrix (~15%).
630									SC	SAND, CLAYEY, LIGHT BROWN hard, medium to coarse grained, silty clay matrix (~60%).
640									SC	BOULDER
650									SC	SAND, CLAYEY, LIGHT BROWN hard, medium to coarse grained, silty clay matrix (~60%), common boulders.
660									SC	CLAY, SILTY, BROWN
670									SC	SAND, CLAYEY, BROWN hard, fine to coarse grained sand with silty clay matrix (~60%), some decomposed granite (~3-5%).
680									SC	SAND, CLAYEY, BROWN hard, fine to coarse grained sand with silty clay matrix (~70%), common boulders.
690									SC	SAND, CLAYEY, BROWN hard, fine to coarse grained sand with silty clay matrix (~60%), common boulders.
700		3-B		0	0	N	---		ML	(hole angle: 1.5 degrees) SAND, CLAYEY, BROWN fine to coarse grained sand with abundant silty clay matrix (~75%).
									ML	CLAY, SILTY, BROWN some medium to coarse grained sand (~15%). ("soil-3-B" collected at 7:30 on 1-24-90)

EBASCO ENVIRONMENTAL

WELL NO. MW-3

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler, T. Tomczyk
 DRILLING COMPANY Beylik
 DRILLING METHOD Mud Rotary

DRILL HOLE DIAMETER (in) 15.75/9.875
 GROUND LEVEL ELEVATION (ft) 1100
 TOTAL DEPTH OF HOLE (ft) 730
 DEPTH TO WATER (ft) 130.50
 DATE (start/finish) 1-11-90 to 1-24-90

DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
700				0	0	N	--		ML	CLAY, SILTY, BROWN some medium to coarse grained sand (~20%). common boulders.
710				0	0	N	--		ML	CLAY, SILTY, GREY some medium to coarse grained sand (~15%).
720				0	0	N	--		ML	CLAY, SILTY, GREY some medium to coarse grained sand (~15%).
730				0	0	N	--		GR	GRANITE, LIGHT BLUE hard, predominantly quartz, feldspar and mafics (40%). (granitic basement encountered at 724 ft.)



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TABLE 6

Sheet L of 7

MP System Casing Installation Log

Project: NASA JET PROPULSION LABORATORY / EBASCO WB Ref: WB 650
Location: PASADENA, CALIFORNIA Hole No: MW3 Installed by: ER/KS/D.NYE/M. LUTER
Hole Depth: 720 ft MP Depth: 688 ft Hole Diameter: 9 3/8" / 4" STEEL Date Installed: FEB 11, 1990
Measurement Datum: ORIGINAL GROUND SURFACE Datum Elevation: _____ Date Drawn: JAN 31 / 90

Depth ft	Geological Description	Geologic Log	MP Casing Log	Serial No. Batch No.	Final Packer Pressure/Volume	Comments	Joint Tests Joint Pass
0	Total length of steel 702'6"		80			82 13:37 ✓ ✓	
	Original ground surface 2'6" below top of steel					81 - 90 psi 13:33 ✓ ✓	
10	Changed Ground Surface then cut off 2'11" of 4" steel		79			80 - 90 psi 13:39 ✓ ✓	
20	Add 8" protective casing 1.5' above 4" casing		78			13:24 ✓ ✓	
30	Center of coupling 1.0' 82					+ 8 Litres	
	Original Ground Surf 1.5' 81		77			+ 8 Litres	
40	6" 16"		76			90 psi 13:20 ✓ ✓	
50			75			90 psi 13:17 ✓ ✓	
60			74			90 psi 13:14 ✓ ✓	
70	4" 15" HP		73			90 psi 13:11 ✓ ✓	
80	Hydraulic Integrity Test 392.7 @ 15:05		72			+ 7 Litres + 5 Litres H ₂ O	
90	392.62 @ 15:16 392.61 @ 15:24		71			90 psi 13:07 ✓ ✓	
	Note: 8" CASING HAS A LOCKABLE TOP.					90 psi 13:04 ✓ ✓	
100	GROUT TO 98' →					90 psi 13:01 ✓ ✓	
						90 psi 12:58 ✓ ✓	

Regular MP Casing MP Packer Settlement Casing

Measurement Port Coupling Pumping Port Coupling Regular Coupling



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Sheet 2 of 7

MP System Casing Installation Log

Project: NASA JET PROPULSION LABORATORY / EBASLO WB Ref: WB 650
 Location: PASADENA, CALIFORNIA Hole No: MW 3 Installed by: ER/KS/D. NYE/M. CUTLER
 Hole Depth: 720 ft MP Depth: 688 ft Hole Diameter: 9 7/8" STEEL Date Installed: FEB. 11, 1990
 Measurement Datum: ORIGINAL GROUND SURFACE Datum Elevation: _____ Date Drawn: JAN 31/90

Depth ft	Geological Description	Geologic Log	MP Casing Log	Serial No. Batch No.	Final Packer Pressure/Volume	Comments	Joint Tests joint pass
100			70			90 psi 12:51	✓ ✓
110	RENSEAL VULCLAY GROUT TO 98'		69			90 psi 12:47	✓ ✓
120			68			+ 7 Litres H ₂ O + 8 Litres H ₂ O	
130	SEAL MATERIAL 1:1 MIX MONTEREY #3 SAND AND RENSEAL		67			90 psi 12:39	✓ ✓
140			66			90 psi 12:36	✓ ✓
150			65			90 psi 12:31	✓ ✓
160			64			90 psi 12:28	✓ ✓
170			63			+ 8 Litres 90 psi + 8 Litres H ₂ O 12:25	✓ ✓
180			62	5260	172.0'	90 psi 12:20	✓ ✓
190			61	2730 3059	182.0'	90 psi 12:16	✓ ✓
			60			90 psi 12:13	✓ ✓
			59			90 psi 12:10	✓ ✓
200							

Regular MP Casing MP Packer Settlement Casing

Measurement Port Coupling Pumping Port Coupling Regular Coupling



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Sheet 3 of 7

MP System Casing Installation Log

Project: NASA JET PROPULSION LABORATORY / EBASCO

WB Ref: WB 650

Location: PASADENA, CALIFORNIA

Hole No: MLJ 3

Installed by: ER/KS/D.NYE/M.CUTLE

Hole Depth: 720 ft MP Depth: 688 ft
ORIGINAL

Hole Diameter: 9 7/8" / 4" STEEL

Date Installed: FEB 11, 1990

Measurement Datum: GROUND SURFACE

Datum Elevation: _____

Date Drawn: JAN 31 / 90

Depth, ft	Geological Description	Geologic Log	MP Casing Log	Serial No. Batch No.	Final Packer Pressure/Volume	Comments	Joint Tests Joint Pass	
200			58			90psi 12:05	✓	✓
210	SEAL MATERIAL 1:1 MIX MONTEREY #3 SAND AND BENSEAL.		57			90psi 12:02	✓	✓
220			56			90psi 11:59	✓	✓
230	FILTER PACK MONTEREY #2 1/2 SAND		55	5262	232.0'	90psi 11:56	✓	✓
240			54	3060		90psi 11:53	✓	✓
250	ZONE B		53			90psi 11:50	✓	✓
260			52	5263	252.0'	90psi 11:47	✓	✓
			51	2737 3061	262.0'	+ 8 litres + 8 litres Tapwater 90psi 11:42	✓	✓
270			50			90psi 11:38	✓	✓
280			49			90psi 11:35	✓	✓
			48			90psi 11:31	✓	✓
290			47			90psi 11:25	✓	✓
			46			90psi 11:23	✓	✓
300			45			90psi 11:28	✓	✓



Regular
MP Casing



MP Packer



Settlement
Casing



Measurement
Port Coupling



Pumping
Port Coupling



Regular
Coupling



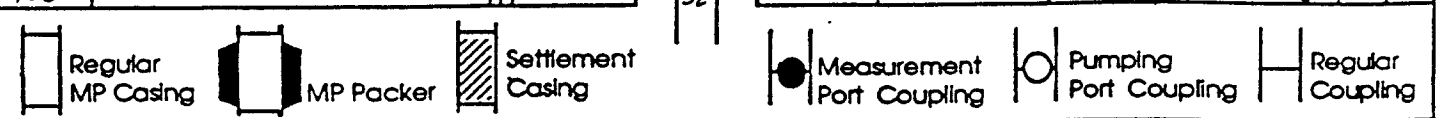
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Sheet 4 of 7

MP System Casing Installation Log

Project: NASA JET PROPULSION LABORATORY / EBASCO WB Ref: WB 650
 Location: PASADENA, CALIFORNIA Hole No: MW 3 Installed by: EQ/KS/D. NYE/M. CUTLER
 Hole Depth: 720 ft MP Depth: 688 ft Hole Diameter: 9 3/4" STEEL Date Installed: FEB 11, 1990
 Measurement Datum: GROUND SURFACE Datum Elevation: _____ Date Drawn: JAN 31/90

Depth, ft	Geological Description	Geologic Log	MP Casing Log	Serial No. Batch No.	Final Packer Pressure/Volume	Comments	Joint Tests joint pass
300							
			44			90 psi 11:20	✓ ✓
310							
			43			90 psi 11:16	✓ ✓
320						Add 9 litres H ₂ O	
			42	5261	326.0'	90 psi 11:11	✓ ✓
330						Add 81 litres H ₂ O	
			41			Pasadena City water from JPL Lab Tap.	
340				3057		90 psi 11:07	✓ ✓
			40			90 psi 11:04	✓ ✓
350			39	5254	346.0'	90 psi 11:00	✓ ✓
			38	2934	356.0'	90 psi 10:56	✓ ✓
360			37	3056		90 psi 10:53	✓ ✓
			36			90 psi 10:47	✓ ✓
370			35			90 psi 10:49	✓ ✓
			34			90 psi 10:43	✓
380							
			33			90 psi 10:40	✓ ✓
390							
400			32			90 psi 10:36	✓ ✓





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Sheet 5 of 7

MP System Casing Installation Log

Project: NASA JET PROPULSION LABORATORY / EBASCO WB Ref: WB 650
 Location: PASADENA, CALIFORNIA Hole No: MLW 3 Installed by: ER/KS/D.NYE/M.CUTLE
 Hole Depth: 720 ft MP Depth: 688 ft Hole Diameter: 9 7/8" STEEL Date Installed: FEB. 11, 1990
 Measurement Datum: ORIGINAL GROUND SURFACE Datum Elevation: _____ Date Drawn: JAN 31/90

Depth Ft	Geological Description	Geologic Log	MP Casing Log	Serial No. Batch No.	Final Packer Pressure/Volume	Comments	Joint Tests joint pass
400							
410			31			90psi 10:32	✓ ✓
420			30			90psi 10:28	✓ ✓
430			29			90psi 10:25	✓ ✓
440			28			90psi 10:09	✓
450			27			90psi 10:06	✓ ✓
460			26			90psi 10:01	✓ ✓
470			25			90psi 9:57	✓ ✓
480			24			90psi 9:54	✓ ✓
490			23			90psi 9:50	✓ ✓
500			22			90psi 9:45	✓ ✓



Regular
MP Casing



MP Packer



Settlement
Casing



Measurement
Port Coupling



Pumping
Port Coupling



Regular
Coupling



Westbay
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Sheet 6 of 7

MP System Casing Installation Log

Project: NASA JET PROPULSION LABORATORY / EBASCO

WB Ref: WB 650

Location: PASADENA, CALIFORNIA

Hole No: MW 3

Installed by: ER/KS/D.NYE/M. CUTZ

Hole Depth: 720 FE MP Depth: 688 FE
ORIGINAL

Hole Diameter: 9 3/4" STEEL Date Installed: FEB. 11, 1990

Measurement Datum: GROUND SURFACE

Datum Elevation: _____ Date Drawn: JAN 31/90

Depth. ft	Geological Description	Geologic Log	MP Casing Log	Serial No. Batch No.	Final Packer Pressure/Volume	Comments	Joint Tests Joint Pass	
500								
510			21			90psi 9:42	✓	✓
520			20			90psi 9:37	✓	✓
530			19			90psi 9:34	✓	✓
540			18	5255	538.0'	9:31 90psi 9:28	✓	✓
550			17	3062		90psi 9:25	✓	✓
560			16			90psi 9:22	✓	✓
570			15	5256	558.0'	90psi 9:19	✓	✓
580			14	2728 3055	568.0'	90psi 9:15	✓	✓
590			13			90psi 9:11	✓	✓
600			12			90psi 9:07	✓	✓
			11			90psi 9:03	✓	✓



Regular
MP Casing



MP Packer



Settlement
Casing



Measurement
Port Coupling



Pumping
Port Coupling



Regular
Coupling



Westbay
Instruments Inc.

Sheet 7 of 7

MP System Casing Installation Log

Project: NASA JET PROPULSION LABORATORY / EBASCO WB Ref: WB 650
 Location: PASADENA, CALIFORNIA Hole No: MLW 3 Installed by: ER/KS/D.NYE/M.CUTLE
 Hole Depth: 720 ft MP Depth: 688 ft Hole Diameter: 9 7/8" STEEL Date Installed: FEB. 11, 1990
 Measurement Datum: ORIGINAL GROUND SURFACE Datum Elevation: _____ Date Drawn: JAN 31/90

Depth, ft.	Geological Description	Geologic Log	MP Casing Log	Serial No. Batch No.	Final Packer Pressure/Volume	Comments	Joint Tests Joint Pass	
600			10			90psi 08:59	✓	✓
610			9			90psi 08:56	✓	✓
620			8			90psi 08:53	✓	✓
630			7	5258	623.0'	90psi 08:49	✓	✓
640			6	3054		90psi 08:45	✓	✓
650			5			90psi 08:41	✓	✓
660			4	5257	653.0'	90psi 08:34	✓	✓
670			3	2731	663.0'	90psi 08:30	✓	✓
680			2	3053	668.0'	90psi 08:26	✓	✓
690			1	5259		90psi 08:21	✓	✓
700						250-160 = 90psi 08:08	✓	✓
						4" STEEL HAS CAP WELDED ON BOTTOM.		
						JOINT TEST TOOL SET TO 160psi 8:00 a.m.		

Regular MP Casing
 MP Packer
 Settlement Casing
 Measurement Port Coupling
 Pumping Port Coupling
 Regular Coupling

WELL MW-4

**BORING LOG AND WELL COMPLETION DIAGRAM
WESTBAY MP CASING INSTALLATION LOG**

WELL NO. MW-4

PROJECT JPL ESI

DRILL HOLE DIAMETER (in) 18.5/12.25

LOCATION Pasadena, California

GROUND LEVEL ELEVATION (ft) 1083

GEOLOGIST/ENGINEER M. Cutler, M. Barnes

TOTAL DEPTH OF HOLE (ft) 605

DRILLING COMPANY Beylik

DEPTH TO WATER (ft) 108.6

DRILLING METHOD Mud Rotary

DATE (start/finish) 1-31-90 to 2-6-90

DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
0									SP	SAND, OLIVE-BROWN coarse-medium grain, angular-subangular, poorly sorted, loose, occasional gravel. BOULDER
10									SP	SAND, OLIVE-BROWN coarse-medium grain, angular-subangular, poorly sorted, loose, occasional gravel. BOULDERS (drilled to 18.5 ft. with 18.5 in. bit; set conductor pipe; continued drilling with 12.25 in. bit)
20									SP	SAND, OLIVE-BROWN coarse-medium grain, angular-subangular, poorly sorted, loose, occasional gravel. BOULDERS ("soil-4-1" collected at 14:15 on 2-1-90)
30		4-1	X	0	0	N			SP	SAND, MULTICOLORED coarse grain, angular-subangular, poorly sorted, abundant boulder fragments. BOULDERS
40				0	0	N			SP	SAND, MULTICOLORED coarse grain, subangular-angular, poorly sorted, loose, abundant gravel.
50				0	0	N			SP	SAND, MULTICOLORED medium-coarse grain, angular-subangular, poorly sorted, abundant gravel.
60				0	0	N			SP	SAND, MULTICOLORED medium-coarse grain, angular-subangular, poorly sorted, occasional gravel.
70				0	0	N			SP	SAND, MULTICOLORED medium-coarse grain, angular-subangular, poorly sorted, occasional gravel, abundant rock fragments (schist).
80				0	0	N			SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, occasional gravel.
90				0	0	N			SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, occasional rock fragments. ("soil-4-2" collected on 2-2-90)
100		4-2	X	0	0	N			SP	

EBASCO ENVIRONMENTAL

WELL NO. MW-4

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler, M. Barnes
 DRILLING COMPANY Bevlik
 DRILLING METHOD Mud Rotary

DRILL HOLE DIAMETER (in) 18.5/12.25
 GROUND LEVEL ELEVATION (ft) 1083
 TOTAL DEPTH OF HOLE (ft) 605
 DEPTH TO WATER (ft) 108.6
 DATE (start/finish) 1-31-90 to 2-6-90

DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
100	<p>LC STEEL CASING 304-SS SCREEN BENTONITE SEAL #2 SAND</p>			0	0	N	---		SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, occasional gravel.
110									SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, some rock fragments.
120									SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose, occasional rock fragments.
130									SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose.
140									SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose. BOULDER
150									SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose, occasional boulder fragments.
160									SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose.
170									SP CL	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose. CLAY, BROWN
180									SP CL	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose. CLAY, SANDY, BROWN
190									SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose.
200		4-3	X	0	0	N	---			("soil-4-3" collected on 2-2-90)

EBASCO ENVIRONMENTAL

WELL NO. MW-4

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler, M. Barnes
 DRILLING COMPANY Beylik
 DRILLING METHOD Mud Rotary

DRILL HOLE DIAMETER (in) 18.5/12.25
 GROUND LEVEL ELEVATION (ft) 1083
 TOTAL DEPTH OF HOLE (ft) 605
 DEPTH TO WATER (ft) 108.6
 DATE (start/finish) 1-31-90 to 2-6-90

DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
200	<p>LC STEEL CASING</p> <p>304-SS SCREEN</p> <p>BENTONITE SEAL</p> <p>#2 SAND</p> <p>BENTONITE SEAL</p>			0	0	N			SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose. BOULDER
210				0	0	N			SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose, occasional granite fragments.
220				0	0	N			SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose, some rock fragments (metamorphic).
230				0	0	N			SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose, some rock fragments (metamorphic).
240				0	0	N			SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose, occasional rock fragments.
250				0	0	N			SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose.
260				0	0	N			SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose.
270				0	0	N			SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose, occasional rock fragments.
280				0	0	N			SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose, occasional rock fragments.
290				0	0	N			SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose, occasional rock fragments.
300		4-4		0	0	N			SP CL	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose, occasional rock fragments. CLAY, SILTY, BROWN ("soil-4-4" collected on 2-2-90)

EBASCO ENVIRONMENTAL

WELL NO. MW-4

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler, M. Barnes
 DRILLING COMPANY Beylik
 DRILLING METHOD Mud Rotary

DRILL HOLE DIAMETER (in) 18.5/12.25
 GROUND LEVEL ELEVATION (ft) 1083
 TOTAL DEPTH OF HOLE (ft) 605
 DEPTH TO WATER (ft) 108.6
 DATE (start/finish) 1-31-90 to 2-6-90

DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
300	LC STEEL CASING 304-SS SCREEN 3 #2 SAND BENTONITE SEAL 304-SS SCREEN 4 #2 SAND			0	0	N			CL	CLAY, SILTY, OLIVE-BROWN SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose.
310				0	0	N			SP CL	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose. CLAY, SILTY, OLIVE-BROWN
320				0	0	N			SP	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose. BOULDER
330				0	0	N			SP CL	CLAY, SILTY, OLIVE-BROWN SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose.
340				0	0	N			SP CL	SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose. CLAY, SILTY, OLIVE-BROWN
350				0	0	N			SP CL	CLAY, SILTY, OLIVE-BROWN SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose.
360				0	0	N			SP CL	CLAY, SILTY, OLIVE-BROWN SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose.
370				0	0	N			SP CL	CLAY, SILTY, OLIVE-BROWN SAND, MULTICOLORED medium to coarse grain, angular-subangular, poorly sorted, loose.
380				0	0	N			SP ML	SILT, CLAYEY, OLIVE-BROWN SAND, MULTICOLORED coarse to medium grain, angular-subangular, poorly sorted, loose.
390				0	0	N			SP ML	SILT, CLAYEY, OLIVE-BROWN SAND, MULTICOLORED coarse to medium grain, angular-subangular, poorly sorted, loose.
400		4-5		0	0	N				("soil-4-5" collected at 11:40 on 2-5-90) ("soil-4-5" collected at 11:40 on 2-5-90)

EBASCO ENVIRONMENTAL

WELL NO. MW-4

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler, M. Barnes
 DRILLING COMPANY Bevlik
 DRILLING METHOD Mud Rotary

DRILL HOLE DIAMETER (in) 18.5/12.25
 GROUND LEVEL ELEVATION (ft) 1083
 TOTAL DEPTH OF HOLE (ft) 605
 DEPTH TO WATER (ft) 108.6
 DATE (start/finish) 1-31-90 to 2-6-90

DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	DOOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
400	LC STEEL CASING			0	0	N	---		SP ML	SILT, CLAYEY, OLIVE-BROWN SAND, MULTICOLORED medium to coarse grain, subangular-angular, poorly sorted, loose.
410										SILT, CLAYEY, OLIVE-BROWN SAND, MULTICOLORED medium to coarse grain, subangular-angular, poorly sorted, loose.
420										SILT, CLAYEY, OLIVE-BROWN SAND, MULTICOLORED medium to coarse grain, subangular-angular, poorly sorted, loose (possibly recirculated material).
430										SILT, CLAYEY, OLIVE-BROWN SAND, MULTICOLORED medium to coarse grain, subangular-angular, poorly sorted, loose (possibly recirculated material).
440										SILT, CLAYEY, OLIVE-BROWN SAND, MULTICOLORED medium to coarse grain, subangular-angular, poorly sorted, loose (possibly recirculated material).
450										SILT, CLAYEY, OLIVE-BROWN SAND, MULTICOLORED medium to coarse grain, subangular-angular, poorly sorted, loose.
460										SILT, CLAYEY, OLIVE-BROWN SAND, MULTICOLORED medium to coarse grain, subangular-angular, poorly sorted, loose.
470										SILT, CLAYEY, OLIVE-BROWN SAND, MULTICOLORED medium to coarse grain, subangular-angular, poorly sorted, loose. BOULDER
480										SILT, CLAYEY, OLIVE-BROWN SAND, MULTICOLORED medium to coarse grain, subangular-angular, poorly sorted.
490										SAND, MULTICOLORED medium to coarse grain, subangular-angular, poorly sorted.
500		4-6		0	0	N	---		SP ML	SILT, CLAYEY, OLIVE-BROWN ("soil-4-6" collected at 15:30 on 2-5-90)

EBASCO ENVIRONMENTAL

WELL NO. MW-4

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler, M. Barnes
 DRILLING COMPANY Beylik
 DRILLING METHOD Mud Rotary

DRILL HOLE DIAMETER (in) 18.5/12.25
 GROUND LEVEL ELEVATION (ft) 1083
 TOTAL DEPTH OF HOLE (ft) 605
 DEPTH TO WATER (ft) 108.6
 DATE (start/finish) 1-31-90 to 2-6-90




DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
500									SP	SILT, CLAYEY, OLIVE-BROWN
				0	0	N	--		ML	SAND, MULTICOLORED medium to coarse grain, subangular-angular, poorly sorted.
510				0	0	N	--		SP	SILT, CLAYEY, OLIVE-BROWN
				0	0	N	--		ML	SAND, MULTICOLORED medium to coarse grain, subangular-angular, poorly sorted.
520				0	0	N	--		SP	SILT, CLAYEY, OLIVE-BROWN
				0	0	N	--		CL	CLAY, SILTY, OLIVE-BROWN SAND, MULTICOLORED medium to coarse grain, subangular-angular, poorly sorted.
530				0	0	N	--		SP	SILT, CLAYEY, OLIVE-BROWN
				0	0	N	--		CL	CLAY, SILTY, OLIVE-BROWN SAND, MULTICOLORED medium to coarse grain, subangular-angular, poorly sorted.
540				0	0	N	--		SP	SILT, CLAYEY, OLIVE-BROWN
				0	0	N	--		CL	CLAY, SILTY, OLIVE-BROWN SILT, CLAYEY, OLIVE-BROWN
550				0	0	N	--		SP	CLAY, SILTY, OLIVE-BROWN
				0	0	N	--		CL	GRANITIC ROCK, LIGHT BUFF hard, 7% mafics.
560				0	0	N	--		GR	(granitic basement rock encountered at 556 ft.)
				0	0	N	--		CL	GRANITIC ROCK, LIGHT BUFF 7% mafics.
570				0	0	N	--		GR	SILT, CLAYEY, OLIVE-BROWN
				0	0	N	--		ML	GRANITIC ROCK, LIGHT BUFF hard, 7% mafics.
580				0	0	N	--		GR	SILT, CLAYEY, GRAY-GREEN
				0	0	N	--		ML	CLAY, SILTY, OLIVE-BROWN GRANITIC ROCK, LIGHT BUFF hard, 7% mafics.
590				0	0	N	--		GR	GRANITIC ROCK, LIGHT BUFF hard, 7% mafics.
600		4-7	X	0	0	N	--			("soil-4-7" collected on 2-6-90)

EBASCO ENVIRONMENTAL

WELL NO. MW-4

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler, M. Barnes
 DRILLING COMPANY Bevlik
 DRILLING METHOD Mud Rotary

DRILL HOLE DIAMETER (in) 18.5/12.25
 GROUND LEVEL ELEVATION (ft) 1083
 TOTAL DEPTH OF HOLE (ft) 605
 DEPTH TO WATER (ft) 108.6
 DATE (start/finish) 1-31-90 to 2-6-90

DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	COOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
600	 			0	0	N	--		GR	GRANITIC ROCK, LIGHT BUFF hard, 7% mafics.



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MP System Casing Installation Log

Project: NASA JET PROPULSION LABORATORY / EBASCO WB Ref: 650
 Location: PASADENA, CALIFORNIA Hole No: MW-4 Installed by: ER/KS/M. BARNES.
 Hole Depth: 605' MP Depth: 547' Hole Diameter: 12 1/4" / 4" STEEL Date Installed: FEB 16 / 90
 Measurement Datum: GROUND SURFACE (ASPHALT) Datum Elevation: _____ Date Drawn: FEB 15 / 90

Depth ft	Geological Description	Geologic Log	MP Casing Log	Serial No. Batch No.	Final Packer Pressure/Volume	Comments	Joint Tests joint pass
0	TEMPORARY EXTENSION { TOP OF MP 3' ABOVE G.L.		69			400162 H ₂ O	
10			68			HYDRAULIC TEST @ 6:37 PM.	
20	MIDPOINT OF COUPLING #69 7 1/2" BELOW GROUND SURFACE (ASPHALT)		67			69 110 psi 18:17	✓ ✓
30	SUBSURFACE COMPLETION		66			68 100 psi 18:17	✓ ✓
40	REMOVABLE EXTENSION		65			67 100 psi 18:16	✓ ✓
50			64			FEB 16 = 311.40 FROM TOP MP ~5 min @ 91	
60			63			adding H ₂ O 9:45 AM FEB 17 311.43 = SELED SYSTEM.	
70			62			105 psi 18:20	✓ ✓
80			61			100 psi 18:00	✓ ✓
90			60			90 psi 17:58	✓ ✓
100			59			100 psi 17:54	✓ ✓
			58			110 psi 17:52	✓ ✓
			57			100 psi 17:48	✓ ✓
						132 psi 17:47	✓ ✓
						100 psi 17:44	✓ ✓
						ADD 14 L	
						130 psi 17:39	✓ ✓
						105 psi 17:37	✓ ✓

Regular MP Casing MP Packer Settlement Casing

Measurement Port Coupling Pumping Port Coupling Regular Coupling



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Sheet 2 of 6

MP System Casing Installation Log

Project: NASA JET PROPULSION LABORATORY / EBASCO WB Ref: 650
 Location: PASADENA, CALIFORNIA Hole No: MW-4 Installed by: ER/KS/M. BARNES
 Hole Depth: 605' MP Depth: 547' Hole Diameter: 12 1/4" / 4" STEEL Date Installed: FEB 16/90
 Measurement Datum: GROUND SURFACE (ASPHALT) Datum Elevation: _____ Date Drawn: FEB 15/90

Depth ft	Geological Description	Geologic Log	MP Casing Log	Serial No. Batch No.	Final Packer Pressure/Volume	Comments	Joint Tests joint pass
100							
110	SEAL MATERIAL 1:1 MIX MONTEREY #3 SAND AND BENSEAL		56			110psi 17:35	✓ ✓
120			55			105psi 17:33	✓ ✓
130	FILTER PACK MONTEREY #2 1/2 SAND		54			105psi 17:31	✓ ✓
140			53	3051		100psi 17:28	✓ ✓
150			52	5121		100psi 17:24	✓ ✓
160			51			ADD 14.2 L H ₂ O 100psi 17:19	✓ ✓
170			50	2732		95psi 17:16	✓ ✓
180			49	3043		80psi 17:13	✓ ✓
190			48			100psi 17:09	✓ ✓
200			47			110psi 17:06	✓ ✓
			46			110psi 17:04	✓ ✓
			45			100psi 17:01	✓ ✓





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Sheet 3 of 6

MP System Casing Installation Log

Project: NASA JET PROPULSION LABORATORY / EBASCO WB Ref: 650
 Location: PASADENA, CALIFORNIA Hole No: MW-4 Installed by: ER/KS/M. BARNES
 Hole Depth: 605' MP Depth: 547' Hole Diameter: 12 1/4" / 4" steel Date Installed: FEB 11/90
 Measurement Datum: GROUND SURFACE / ASPHALT Datum Elevation: _____ Date Drawn: FEB 15/90

Depth, ft	Geological Description	Geologic Log	MP Casing Log	Serial No. / Batch No.	Final Packer Pressure/Volume	Comments	Joint Tests joint pass
200							
210			44			120psi 16=56 ADD 16.2 H ₂ O	✓ ✓
220			43	5273 QA9	219.6'	120psi 16=51	✓ ✓
230	8 ZONE		42	3050		100psi 16=47	✓ ✓
240		237.2 SCREEN	41	5264	239.6'	100psi 16=40	✓ ✓
250		247.2	39	2729 3049	249.6'	100psi 16=35	✓ ✓
260			38			100psi 16=30	✓ ✓
			37			110psi 16=22	✓ ✓
270			36			110psi 16=26	✓ ✓
280			35			120psi 16=17	✓ ✓
290			34			100psi 16=14	✓ ✓
300			33			115psi 16=10	✓ ✓

Regular MP Casing
 MP Packer
 Settlement Casing

Measurement Port Coupling
 Pumping Port Coupling
 Regular Coupling



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Sheet 5 of 6

MP System Casing Installation Log

Project: NASA JET PROPULSION LABORATORY / EBASCO WB Ref: 650
 Location: PASADENA, CALIFORNIA Hole No: MW-4 Installed by: ER/KS/MIKE BARNES
 Hole Depth: 605' MP Depth: 547' Hole Diameter: 12 1/4" / 4" STEEL Date Installed: FEB 16, 1990
 Measurement Datum: GROUND SURFACE / ASPHALT Datum Elevation: _____ Date Drawn: FEB 15, 1990

Depth, ft	Geological Description	Geologic Log	MP Casing Log	Serial No. Batch No.	Final Packer Pressure/Volume	Comments	Joint Tests joint pass
300			32	5267 QA7	301.6'	95psi 16:07	✓ ✓
310			31	3048		16:04 ✓ 110psi LEAKS REPAIR 15:59	✓ ✓
320	ZONE 6	319.6	30	5120	321.6'	110psi 15:54	✓ ✓
330		329.6	29	2735 3044	331.6	105psi 15:51	✓ ✓
340			28			105psi 15:48	✓ ✓
350			27			100psi 15:45	✓ ✓
360			26			105psi 15:41	✓ ✓
370			25			105psi 15:39	✓ ✓
380	ZONE 4	388.9	24	5119 QA5	371.6'	105psi 15:32	✓ ✓
390			23	3052		110psi 15:29	✓ ✓
400		398.9	22	5265	391.6	105psi 15:25	✓ ✓
			21			95psi 15:23	✓ ✓
			20				

Regular MP Casing MP Packer Settlement Casing

Measurement Port Coupling Pumping Port Coupling Regular Coupling



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Sheet 5 of 6

MP System Casing Installation Log

Project: NASA JET PROPULSION LABORATORY / EBASCO WB Ref: 650
 Location: PASADENA, CALIFORNIA Hole No: MW-4 Installed by: FR/ICS M. BARNES
 Hole Depth: 605' MP Depth: 547' Hole Diameter: 12 1/4" / 4" STEEL Date Installed: FEB 16/90
 Measurement Datum: GROUND SURFACE / ASPHALT Datum Elevation: _____ Date Drawn: FEB 15, 1990

Depth, Ft	Geological Description	Geologic Log	MP Casing Log	Serial No. Batch No.	Final Packer Pressure/Volume	Comments	Joint Tests joint pass	
400		o o o	19	2733	401.6'	110psi 15:16	✓	✓
		o o o	18	3045		180psi 15:09	✓	✓
410	4	o o o						
	ZONE	o o o	17			105 psi 15:04	✓	✓
		o o o	16			110 psi 14:56	✓	✓
420		o o o	15			115 psi 14:59	✓	✓
		o o o	14			95 psi 15:01	✓	✓
430		/ / /						
		/ / /	13			180 psi 14:52	✓	✓
440		/ / /						
		/ / /	12			100 psi 14:47	✓	✓
450		/ / /						
		/ / /	11			95 psi 14:42	✓	✓
460		/ / /						
		/ / /	10			100 psi 14:39	✓	✓
470		/ / /						
		/ / /	9			100 psi 14:36	✓	
480		o o o						
		o o o	8			80 psi 14:32	✓	
490	2	o o o						
	ZONE	o o o	7	4231	492.6'	80 psi 14:29	✓	✓
		o o o		QA3				
500		o o o						

Regular MP Casing MP Packer Settlement Casing

Measurement Port Coupling Pumping Port Coupling Regular Coupling



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Sheet 6 of 6

MP System Casing Installation Log

Project: NASA JET PROPULSION LABORATORY / EBASCO WB Ref: 650
 Location: PASADENA, CALIFORNIA Hole No: MW-4 Installed by: ER/KS/M. BARNES
 Hole Depth: 605' MP Depth: 547' Hole Diameter: 1 1/4" / 4" STEEL Date Installed: FEB 16/90
 Measurement Datum: GROUND SURFACE / ASPHALT Datum Elevation: _____ Date Drawn: FEB 15, 1990

Depth, ft.	Geological Description	Geologic Log	MP Casing Log	Serial No. Batch No.	Final Packer Pressure/Volume	Comments	Joint Tests
500		0 0 0	6	3046		70 psi 14:25	✓ ✓
		0 0	5			90 psi 14:19	✓ ✓
510	ZONE 2	509.4	4	5269	512.6'	90 psi 14:15	✓ ✓
		0 0 0	3	2736	522.6'		
520		519.4	2	3047		90 psi 14:11	✓ ✓
		0 0 0	1	5266	527.6'	90 psi 14:06	✓ ✓
530				QA1			
						90 psi 14:01	✓ ✓
540						90 psi 13:51	✓ ✓
						Inflation tool valve set at 150 psi	
550						Set supply @ 240 psi	
						BOTTOM OF 4" STEEL 559.6'	
560							
570							
580							
590							
600						TD OF HOLE = 605 ft.	

Regular MP Casing MP Packer Settlement Casing

Measurement Port Coupling Pumping Port Coupling Regular Coupling

WELL MW-5

BORING LOG AND WELL COMPLETION DIAGRAM

EBASCO ENVIRONMENTAL

WELL NO. MW-5

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler, M. Barnes
 DRILLING COMPANY Bevlik
 DRILLING METHOD Percussion Hammer

DRILL HOLE DIAMETER (in) 11
 GROUND LEVEL ELEVATION (ft) 1070
 TOTAL DEPTH OF HOLE (ft) 145
 DEPTH TO WATER (ft) 98.43
 DATE (start/finish) 2-12-90 to 2-13-90

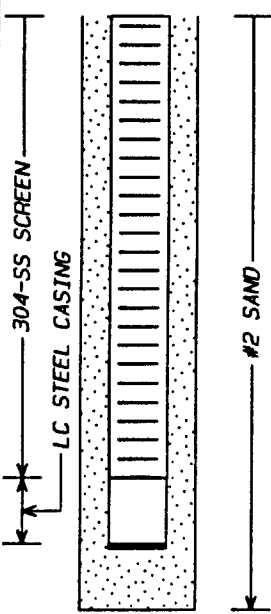
DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
0	<p>LC STEEL CASING</p> <p>CONCRETE</p> <p>VOLCLAY GROUT</p> <p>BENTONITE SEAL</p> <p>#2 SAND</p> <p>304-SS SCREEN</p>	5-1		0	0	N	SM		SW	SAND, OLIVE-BROWN coarse-fine grained, subangular, poorly sorted, abundant gravel ("soil-5-1" collected at 9:15 on 2-12-90)
10				0	0	N	SM		SW	SAND, OLIVE-BROWN fine-coarse grained, subangular, v. poorly sorted, abundant cobbles up to 6 cm.
20				0	0	N	SM		SW	SAND, RED-BROWN fine-coarse grained, subangular, v. poorly sorted, abundant gravel up to 3 cm.
30				0	0	N	SM		SW	SAND, RED-BROWN fine-coarse grained, subangular, v. poorly sorted, occasional gravel up to 3 cm.
40		5-2		0	0	N	SM		SW	SAND, RED-BROWN fine-coarse grained, subangular, v. poorly sorted, occasional gravel.
50				0	0	N	SM		SW	SAND, RED-BROWN fine-coarse grained, subangular-subrounded, poorly sorted, abundant gravel up to 2 cm ("soil-5-2" collected at 10:00 on 2-12-90)
60				0	0	N	SM		SW	SAND, TAN-MEDIUM BROWN fine-coarse grained, subangular, poorly sorted, abundant gravel up to 2 cm.
70				0	0	N	DR		SW CL	SAND, SILTY, TAN fine-coarse grained, subangular, poorly sorted, some gravel, boulder at 73 ft., and CLAY, TAN
80		5-3		0	0	N	--		SW	SAND, TAN-RED BROWN fine-coarse grained, subangular, poorly sorted, some gravel, boulder at 84 ft.
90				0	0	N	--		SW	SAND, OLIVE BROWN-RED BROWN medium-coarse grained, subangular-angular, poorly sorted, occasional gravel up to 1.5 cm.
100				0	0	N	--		SW	("soil-5-3" collected at 15:30 on 2-12-90)

EBASCO ENVIRONMENTAL

WELL NO. MW-5

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler, M. Barnes
 DRILLING COMPANY Bevlik
 DRILLING METHOD Percussion Hammer

DRILL HOLE DIAMETER (in) 11
 GROUND LEVEL ELEVATION (ft) 1070
 TOTAL DEPTH OF HOLE (ft) 145
 DEPTH TO WATER (ft) 98.43
 DATE (start/finish) 2-12-90 to 2-13-90

DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
100				0	0	N	WT	SM	SM	SAND, SILTY, BROWN medium-coarse grained, subangular-angular, poorly sorted, occasional gravel up to 1 cm.
110				0	0	N	WT	SP	SP	SAND, SILTY, BROWN coarse grained, subangular, poorly sorted, occasional gravel up to 1.5 cm.
120				0	0	N	WT	SM	SM	SAND, SILTY, BROWN coarse grained, subangular, poorly sorted, occasional gravel up to 2 cm.
130				0	0	N	WT	SW	SW	SAND, MULTICOLORED coarse grained, subangular, moderately sorted, occasional gravel.
140		5-4	⊗	0	0	N	WT	SW	SW	SAND, MULTICOLORED coarse grained, subangular, moderately sorted, occasional gravel.

WELL MW-6

BORING LOG AND WELL COMPLETION DIAGRAM

EBASCO ENVIRONMENTAL

WELL NO. MW-6

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler, H. Papenguth
 DRILLING COMPANY Beylik
 DRILLING METHOD Percussion Hammer

DRILL HOLE DIAMETER (in) 11
 GROUND LEVEL ELEVATION (ft) 1189
 TOTAL DEPTH OF HOLE (ft) 247
 DEPTH TO WATER (ft) 205.8
 DATE (start/finish) 2-15-90 to 2-24-90

DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	GVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
0		6-1	X	0	0	N	SM		SW	SAND, SILTY, BROWN medium grain, silty, subangular, moderately sorted, abundant gravel and cobbles. ("soil-6-1" collected at 14:45 on 2-15-90)
10				0	0	N	SM		SW	SAND, SILTY, BROWN medium grain, subangular, moderately sorted.
20				0	0	N	SM		SW	SAND, SILTY, BROWN-RED BROWN medium grain, subangular, moderately sorted, occasional gravel.
30				0	0	N	SM		SW	SAND, SILTY, BROWN fine grain, subangular, moderately sorted, occasional gravel up to 1 cm.
40				0	0	N	SM		SW	SAND, SILTY, BROWN fine grain, subangular, moderately sorted, occasional gravel up to 1 cm.
50		6-2	X	0	0	N	SM		SW	("soil-6-2" collected at 15:20 on 2-15-90) SAND, SILTY, BROWN fine grain, subangular, moderately sorted, occasional gravel up to 1 cm.
60				0	0	N	SM		SW	SAND, SILTY, BROWN fine grain, subangular, moderately sorted, occasional gravel up to 1 cm.
70				0	0	N	SM		SW	SAND, SILTY, BROWN fine grain, subangular, moderately sorted, occasional gravel up to 1 cm.
80				0	0	N	SM		SW	SAND, SILTY, BROWN fine grain, subangular, moderately sorted, occasional gravel up to 1 cm.
90				0	0	N	SM		SW	SAND, SILTY, BROWN fine grain, subangular, moderately sorted, occasional gravel up to 1 cm.
100				0	0	N	SM		SW	SAND, BROWN medium grain, subangular, moderately sorted, occasional gravel up to 2 cm. BOULDER ("soil-6-3" collected at 16:40 on 2-15-90)

EBASCO ENVIRONMENTAL

WELL NO. MW-6

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler, H. Papenquith
 DRILLING COMPANY Bevlik
 DRILLING METHOD Percussion Hammer

DRILL HOLE DIAMETER (in) 11
 GROUND LEVEL ELEVATION (ft) 1189
 TOTAL DEPTH OF HOLE (ft) 247
 DEPTH TO WATER (ft) 205.8
 DATE (start/finish) 2-15-90 to 2-24-90

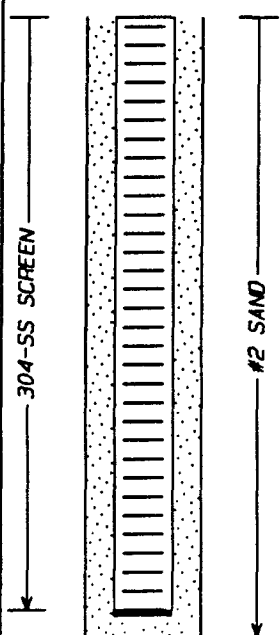
DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
100		6-3	☒	0	0	N	SM		SW	SAND, BROWN medium grain, subangular, moderately sorted, occasional gravel up to 2 cm.
110				0	0	N	SM		SW	SAND, BROWN medium grain, gravelly, subangular, moderately sorted.
120				0	0	N	SM		SW	SAND, BROWN medium grain, gravelly, subangular, moderately sorted.
130				0	0	N	SM		SW	SAND, BROWN medium grain, gravelly, subangular, moderately sorted.
140				0	0	N	SM		SM	SAND, SILTY, BROWN fine to coarse grained, occasional pebbles and cobbles of granitic rock.
150		6-4	☒	0	0	N	SM		SW	BOULDER ("soil-6-4" collected at 8:00 on 2-16-90) SAND, SILTY, BROWN fine to coarse grained, occasional pebbles and cobbles.
160				0	0	N	SM		SW	SAND, SILTY, BROWN fine to coarse grained, occasional pebbles and cobbles.
170				0	0	N	SM		SW	SAND, BROWN very fine to coarse grained, poorly sorted, occasional gravel to cobbles.
180				0	0	N	SM		SW ML	SAND, BROWN very fine to coarse grained, abundant silt and clay, few pebbles, and SILT, CLAYEY, BROWN-GRAY
190				0	0	N	SM		SW	GRANITIC ROCK SAND, BROWN fine to very coarse grained, abundant subrounded gravel.
200		6-5	☒							BOULDER ("soil-6-5" collected at 14:15 on 2-16-90)

EBASCO ENVIRONMENTAL

WELL NO. MW-6

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler, H. Papenquth
 DRILLING COMPANY Bevlik
 DRILLING METHOD Percussion Hammer

DRILL HOLE DIAMETER (in) 11
 GROUND LEVEL ELEVATION (ft) 1189
 TOTAL DEPTH OF HOLE (ft) 247
 DEPTH TO WATER (ft) 205.8
 DATE (start/finish) 2-15-90 to 2-24-90

DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
200		6-6	X	0	0	N	WT		SW	SAND, BROWN fine to medium grained, abundant silt and clay, moderately sorted, abundant biotite, some metamorphic rock fragments. BOULDERS
210									SW	SAND, BROWN fine to medium grained, abundant silt and clay, moderately sorted, abundant biotite, occasional igneous and metamorphic rock fragments. BOULDERS
220									SW	SAND, SILTY, BROWN coarse grained, abundant clay, moderately sorted, igneous and metamorphic rock fragments, abundant gravel up to 8mm.
230									SW	SAND, SILTY, BROWN coarse grained, abundant clay, moderately sorted, igneous and metamorphic rock fragments, abundant gravel up to 8mm.
240									SW	SAND, SILTY, BROWN coarse grained, abundant clay, moderately sorted, igneous and metamorphic rock fragments, abundant gravel up to 8mm. ("soil-6-6" collected at 8:10 on 2-23-90)

WELL MW-7

BORING LOG AND WELL COMPLETION DIAGRAM

EBASCO ENVIRONMENTAL

WELL NO. MW-7

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler
 DRILLING COMPANY Beylik
 DRILLING METHOD Percussion Hammer

DRILL HOLE DIAMETER (in) 11
 GROUND LEVEL ELEVATION (ft) 1213
 TOTAL DEPTH OF HOLE (ft) 276
 DEPTH TO WATER (ft) 236.2
 DATE (start/finish) 2-28-90 to 3-5-90

DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	DVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
0		7-1		0	0	N	SM		SC	SAND, BROWN very fine to coarse grained, abundant silt and clay, subangular, poorly sorted, common gravel and pebbles. ("soil-7-1" collected at 11:00 on 2-28-90)
10				0	0	N	SM		SC	SAND, BROWN very fine to coarse grained, abundant silt and clay, poorly sorted, common gravel.
20				0	0	N	SM		SC	SAND, BROWN very fine to medium grained, abundant silt and clay, poorly sorted, abundant cobbles of granite rock.
30		7-2		0	0	N	SM		SC	SAND, BROWN very fine to coarse grained, abundant silt and clay, subangular, poorly sorted, abundant pebbles and cobbles.
40				0	0	N	SM		SC	SAND, BROWN very fine to coarse grained, common silt, abundant gravel and pebbles.
50				0	0	N	SM		SC	SAND, BROWN very fine to coarse grained, common silt, abundant gravel and pebbles. BOULDERS
60		7-3		0	0	N	SM		SC	SAND, BROWN fine to very coarse grained, abundant pebbles and cobbles.
70				0	0	N	SM		SC	SAND, BROWN fine to very coarse grained, abundant pebbles and cobbles.
80				0	0	N	SM		SC	SAND, BROWN very fine to coarse grained, abundant silt, subangular, poorly sorted, common gravel.
90		7-3		0	0	N	SM		SM	SAND, LIGHT BROWN fine to very coarse grained, subangular, poorly sorted, loose, abundant gravel.
100										("soil-7-3" collected at 13:05 on 2-28-90)

EBASCO ENVIRONMENTAL

WELL NO. MW-7

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler
 DRILLING COMPANY Beylik
 DRILLING METHOD Percussion Hammer

DRILL HOLE DIAMETER (in) 11
 GROUND LEVEL ELEVATION (ft) 1213
 TOTAL DEPTH OF HOLE (ft) 276
 DEPTH TO WATER (ft) 236.2
 DATE (start/finish) 2-28-90 to 3-5-90

DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	ODOR	MOISTURE	SYMBOLS	USCS	DESCRIPTION AND NOTES
100	LC STEEL CASING VOL CLAY GROUT	7-4	X	0	0	N	SM		SM	SAND, BROWN fine to very coarse grained, subangular, poorly sorted, common silt, common gravel and pebbles.
110				0	0	N	SM		SC	SAND, BROWN fine to very coarse grained, subangular, poorly sorted, with trace silt and clay. BOULDERS
120				0	0	N	DR		SC	SAND, BROWN fine to very coarse grained, subangular, poorly sorted, common silt, abundant pebbles and cobbles.
130				0	0	N	DR		SM	SAND, BROWN fine to very coarse grained, subangular, poorly sorted, with trace of clay and silt.
140				0	0	N	DR		SM	SAND, BROWN fine to very coarse grained, subangular, poorly sorted, common silt, common gravel and pebbles.
150				0	0	N	DR		SM	("soil-7-4" collected at 14:15 on 2-28-90) SAND, BROWN fine to very coarse grained, subangular, poorly sorted, common silt, common gravel and pebbles.
160		7-5	X	0	0	N	DR		SM	BOULDER SAND, BROWN fine to very coarse grained, subangular, poorly sorted, common silt, common gravel and pebbles.
170				0	0	N	SM		SM	SAND, BROWN fine to coarse grained, abundant silt, subangular, poorly sorted, common gravel and pebbles.
180				0	0	N	DR		SM	SAND, BROWN fine to very coarse grained, abundant silt, subangular, poorly sorted, abundant gravel to cobble sized granitic rocks.
190				0	0	N	DR		SM	SAND, BROWN fine to very coarse grained, abundant silt, subangular, poorly sorted, abundant gravel and cobble sized rocks.
200				0	0	N	DR		SM	SAND, BROWN fine to very coarse grained, abundant silt, subangular, poorly sorted, abundant gravel and cobble sized rocks. ("soil-7-5" collected at 16:50 on 2-28-90)

EBASCO ENVIRONMENTAL

WELL NO. MW-7

PROJECT JPL ESI
 LOCATION Pasadena, California
 GEOLOGIST/ENGINEER M. Cutler
 DRILLING COMPANY Beylik
 DRILLING METHOD Percussion Hammer

DRILL HOLE DIAMETER (in) 11
 GROUND LEVEL ELEVATION (ft) 1213
 TOTAL DEPTH OF HOLE (ft) 276
 DEPTH TO WATER (ft) 236.2
 DATE (start/finish) 2-28-90 to 3-5-90





DEPTH (ft)	WELL/BORING COMPLETION	SAMPLE #	SAMPLES	OVA (ppm)	% LEL	DOOR	MOISTURE	SYMBOLS	USCS SYMBOL	DESCRIPTION AND NOTES
200	<p>304-SS CASING</p> <p>304-SS SCREEN</p> <p>#2 SAND</p> <p>BENTONITE SEAL</p>								SM	SAND, BROWN fine to very coarse grained, abundant silt, subangular, poorly sorted, abundant gravel and cobble sized granitic rocks.
210				0	0	N	DR		SM	SAND, BROWN fine to very coarse grained, abundant silt, subangular, poorly sorted, abundant gravel and cobble sized granitic rocks.
220				0	0	N	DR		SC	SAND, BROWN fine to very coarse grained, abundant silt, subangular, poorly sorted, abundant silt and clay, common pebbles of granitic rocks.
230				0	0	N	DR		SC	BOULDER
240				0	0	N	ST		SM	SAND, BROWN fine to very coarse grained, abundant silt, subangular, poorly sorted, abundant clay, pebbles, and cobbles, and boulders of granitic rocks.
250		7-6	⊗						SM	BOULDER ("soil-7-6" collected at 10:00 on 3-2-90)
260				0	0	N	ST		SW	SAND, BROWN fine to very coarse grained, abundant silt, subangular, poorly sorted, abundant cobbles.
270		7-7	⊗	0	0	N	ST		SW	BOULDER SAND, BROWN medium to coarse grained, subangular to subrounded, moderately sorted, abundant cobbles. BOULDER ("soil-7-7" collected at 8:10 on 3-5-90)

WELL MW-8

BORING LOG AND WELL COMPLETION DIAGRAM

Monitoring Well 8

DRILLING METHOD Dual-wall air percussion
SAMPLING METHOD Grab samples
SURFACE ELEVATION 1140.1
TOTAL DEPTH (ft) 220.0
DEPTH TO WATER (ft) 166.6

Depth (ft)	Well Completion	Sample No.	Samples	OVA (ppm)			Lithology	USCS Symbol	Lithologic Description and Notes	
				Drill Pipe	Sample	Breath Zn				
100		MW-8-3A MW-8-3B		0	0	0		GP	Cobbles from 101' to 111'.	
110				0	0	0				Cobbles and boulders from 112.5' to 123'.
120				0	0	0				Sandy fine gravel from 123' to 126', slightly moist, very dense. Cobbles (boulder?) at 127'.
130				0	0	0			SP	GRAVELLY SAND - Gravelly fine to coarse sand with trace silt, light orange-brown, slightly moist, very dense, micaceous. Occasional cobbles from 133' to 139'.
140				0	0	0			Cobbles (small boulders) from 142' to 145'.	
150		MW-8-4A MW-8-4B		0	0	0			GP	SANDY GRAVEL - Fine to coarse sandy gravel with cobbles occasional boulders, light yellow-brown to orange-brown, slightly moist, very dense, trace mica.
160				0	0	0		SP	GRAVELLY SAND - Gravelly fine to coarse sand with trace silt, dark orange-brown, slightly moist, very dense, micaceous. Occasional cobbles or small boulders from 156' to 166'.	
170				0	0	0			GP	SANDY GRAVEL - Medium to coarse sandy gravel, dark orange-brown, moist, very dense. Boulder at 173' to 178'.
180				0	0				Encounter groundwater at 180'.	
190									SP	SAND - Medium to coarse sand with trace fine gravel, light brown, saturated, very dense.
200										

Monitoring Well 8

DEPTH TO WATER (ft) 166.6

Depth (ft)	Well Completion	Sample No.	Samples	OVA (ppm)		Lithology	USCS Symbol	Lithologic Description and Notes
				Drill Pipe	Sample			
200		MW-8-5A MW-8-5B					SP SW	Cobbles at 203'. GRAVELLY SAND - Medium to coarse sandy gravel, light brown, saturated, very dense. Total depth = 220' Natural gamma log completed 10/28/92 Static water level at 166.6' bgs (0810, 10/29/92) Converted to monitoring well on 10/29/92.
210								
220								
230								
240								
250								
260								
270								
280								
290								
300								

WELL CONSTRUCTION LOG

PROJECT NAME: JPL Phase I RI/FS

WELL NUMBER: MW-8

PROJECT OFS: JPL 3723.001

WELL LOCATION: North Side Bldg. 303

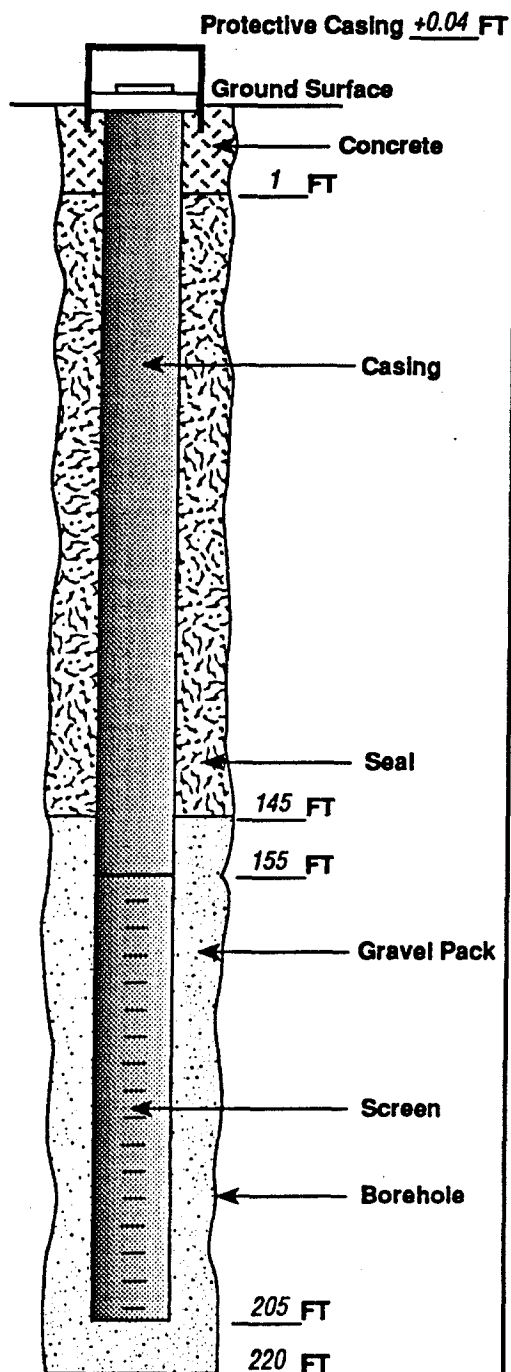
LOCATION: 4800 Oak Grove Dr.

SURFACE ELEV (ft above MSL): Approximately 1140.1

Pasadena, CA

CASING ELEV (ft above MSL): 1139.53

EBASCO PERSONNEL: B.G. Randolph / Rob Tweidt



DRILLING SUMMARY

DATE: 10/29/92

DRILLING COMPANY: Layne Environmental, Inc.

DRILLING FOREMAN: Steve Johnson

RIG TYPE: Portadrill 10 TLT-320

TOTAL DEPTH OF BORING: 220 feet

SURFACE CONDUCTOR CASING (length, diameter): None

DRILLING FLUID: Air

CONSTRUCTION LOG

WELL TYPE: Monitoring

BORING DIAMETER: 10.75 inches

TOTAL WELL DEPTH: 205 feet

CASING TYPE: Stainless Steel Type 304

CASING DIAMETER: 4 inches

CASING LENGTH: 155 feet

SCREEN TYPE: Stainless Steel Type 304

SCREEN SIZE: 0.010 inches

SCREEN LENGTH: 50 feet

TAILPIPE LENGTH: None

CASING STICKUP: +0.04 feet

PROTECTIVE CASING TYPE: DOT Approved Traffic Box

PROTECTIVE CASING STICKUP: 0.5 inch

CENTRALIZERS: None

SEAL MATERIAL: Enviroplug 1/4" Bentonite Pellets

SEAL VOLUME: 75.4 cubic feet

FILTER MATERIAL: RMC Lonestar #2/12 Sand

FILTER VOLUME: 34.15 cubic feet

COMMENTS: Concrete in top 1 foot

WELL MW-9

BORING LOG AND WELL COMPLETION DIAGRAM

EBASCO ENVIRONMENTAL

Monitoring Well 9

PROJECT Jet Propulsion Laboratory
 LOCATION In Arroyo near Building 103
 GEOLOGIST Rob Tweidt/B.G. Randolph
 DRILLING CO Layne Environmental
 DATE (start/finish) 10/22/92

DRILLING METHOD Dual-wall air percussion
 SAMPLING METHOD Grab samples
 SURFACE ELEVATION 1104.5
 TOTAL DEPTH (ft) 70.0
 DEPTH TO WATER (ft) 24.7

Depth (ft)	Well Completion	Sample No.	Samples	OVA (ppm)		Lithology	USCS Symbol	Lithologic Description and Notes
				Drill Pipe	Sample			
0		MW-9-1A					SM	SILTY SAND - Silty fine to medium sand with some gravel, pale brown, dry, medium dense, slightly moist at 4', trace mica.
		MW-9-1B						
10				.4	0			Boulder at 10.5' to 12'.
							SP	SAND - Fine to medium sand with fine to coarse gravel and occasional cobbles, yellow-brown, slightly moist to moist, medium dense, trace mica.
20				0	0			Very moist at 25'.
30				0	.5			Increase in gravel and cobbles.
								Boulder 32' to 36'.
								Groundwater at 33'.
40				.5	0			
							SM	SILTY SAND - Silty fine to medium sand with trace gravel, yellow-brown, saturated, dense, trace mica.
50		MW-9-2A		0	.2			
		MW-9-2B						
							SW GW	GRAVELLY SAND/SANDY GRAVEL - Fine to coarse sandy gravel, yellow-brown, saturated, dense, trace mica.
60				0	.1			
							SP	SAND - Fine to medium sand with trace gravel, yellow-brown, saturated, trace mica.
70				0	0			Fine sand with trace silt.
								Total depth = 70' bgs (10/22/92) Natural gamma log (10/22/92) Static water level at 24.7' bgs (0730, 10/23/92) Converted to monitoring well (10/23/92).
80								
90								
100								

WELL CONSTRUCTION LOG

PROJECT NAME: JPL Phase I RI/FS

PROJECT OFS: JPL 3723.001

LOCATION: 4800 Oak Grove Dr.

Pasadena, CA

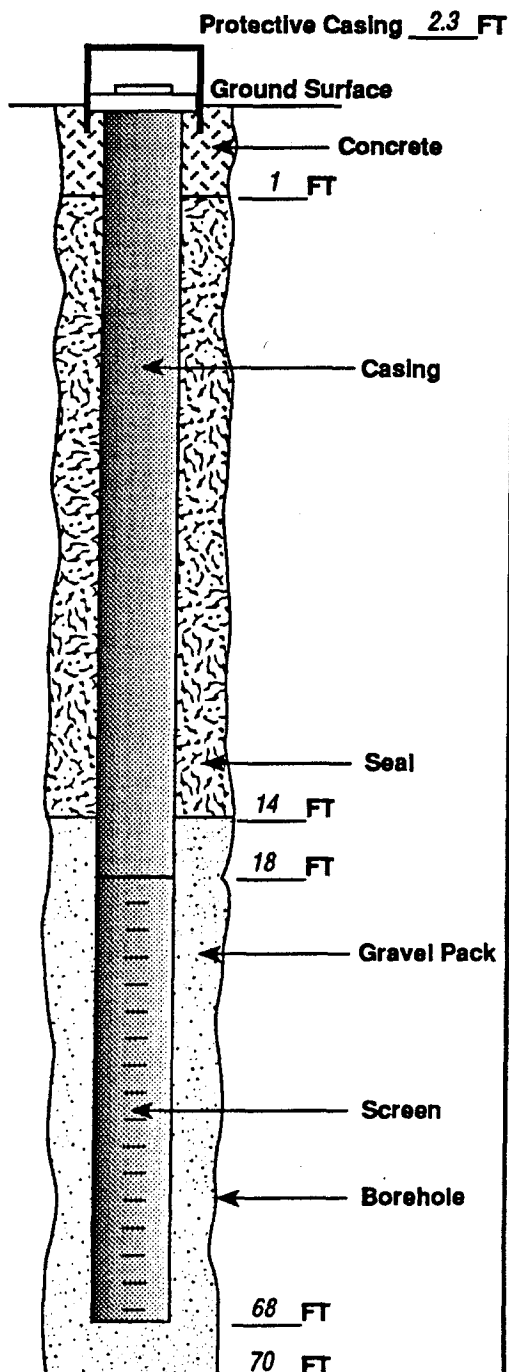
EBASCO PERSONNEL: B.G. Randolph / Rob Tweidt

WELL NUMBER: MW-9

WELL LOCATION: Arroyo Seco

SURFACE ELEV (ft above MSL): Approximately 1104.5

CASING ELEV (ft above MSL): 1106.02



DRILLING SUMMARY

DATE: 10/23/92

DRILLING COMPANY: Layne Environmental, Inc.

DRILLING FOREMAN: Steve Johnson

RIG TYPE: Portadrill 10 TLT-320

TOTAL DEPTH OF BORING: 70 feet

SURFACE CONDUCTOR CASING (length, diameter) None

DRILLING FLUID Air

CONSTRUCTION LOG

WELL TYPE: Monitoring

BORING DIAMETER: 10.75 inches

TOTAL WELL DEPTH: 68 feet

CASING TYPE: Sch. 40 PVC

CASING DIAMETER: 4 inches

CASING LENGTH: 20 feet

SCREEN TYPE: Stainless Steel Type 304

SCREEN SIZE: 0.010 inches

SCREEN LENGTH: 50 feet

TAILPIPE LENGTH: 0.32 feet

CASING STICKUP: 1.5 feet

PROTECTIVE CASING TYPE: Low Carbon Steel

PROTECTIVE CASING STICKUP: 2.3 feet

CENTRALIZERS: None

SEAL MATERIAL: Enviroplug 1/4" Bentonite Pellets

SEAL VOLUME: 5.72 cubic feet

FILTER MATERIAL: RMC Lonestar #2/12 Sand

FILTER VOLUME: 29.34 cubic feet

COMMENTS: Used Six Bags Concrete

(Top Three Feet of Annulus)

WELL MW-10

BORING LOG AND WELL COMPLETION DIAGRAM

EBASCO ENVIRONMENTAL

Monitoring Well 10

PROJECT Jet Propulsion Laboratory

LOCATION Between Buildings 190 and 201

GEOLOGIST Rob Tweidt/B.G. Randolph

DRILLING CO Layne Environmental

DATE (start/finish) 10/30/92

DRILLING METHOD Dual-wall air percussion

SAMPLING METHOD Grab samples

SURFACE ELEVATION 1088.3

TOTAL DEPTH (ft) 170.0

DEPTH TO WATER (ft) 116.1

Depth (ft)	Well Completion	Sample No.	Samples	OVA (ppm)			Lithology	USCS Symbol	Lithologic Description and Notes
				Drill Pipe	Sample	Breath Zn			
0									ASPHALT - Pavement (3 inches thick)
		MW-10-1A MW-10-1B						SP	SAND - Fine to medium sand with trace fine gravel, light brown, fine to medium grained, slightly moist, dense.
10				0	0	0			Boulder from 14' to 19'.
20				0	0	0			Fine grained sand with trace silt.
30				0	0	0			Fine to medium sand with trace fine to coarse gravel.
40				0	0	0		GP	SANDY GRAVEL - Medium to coarse sandy gravel, slightly moist, dense.
50		MW-10-2A MW-10-2B		0	0	0		SP	SAND - Fine to medium sand with some fine gravel, light brown, moist, very dense.
60				0	0	0			Trace silt.
70				0	0	0		SM	SILTY SAND - Silty fine sand with trace fine gravel, brown, micaceous.
				0	0	0		SP	SAND - Fine sand with trace meium sand and fine gravel, moist, very dense, trace mica.
80				0	0	0			Boulder at 75' to 77'. Occassional cobbles.
90				0	0	0		SW	Cobble layer 86' to 88'. GRAVELLY SAND - Gravelly fine to medium sand with trace silt, brown, moist, trace mica.
100				0	0	0			

WELL CONSTRUCTION LOG

PROJECT NAME: JPL Phase I RI/FS

WELL NUMBER: MW-10

PROJECT OFS: JPL 3723.001

WELL LOCATION: Between Bldgs. 190 and 201

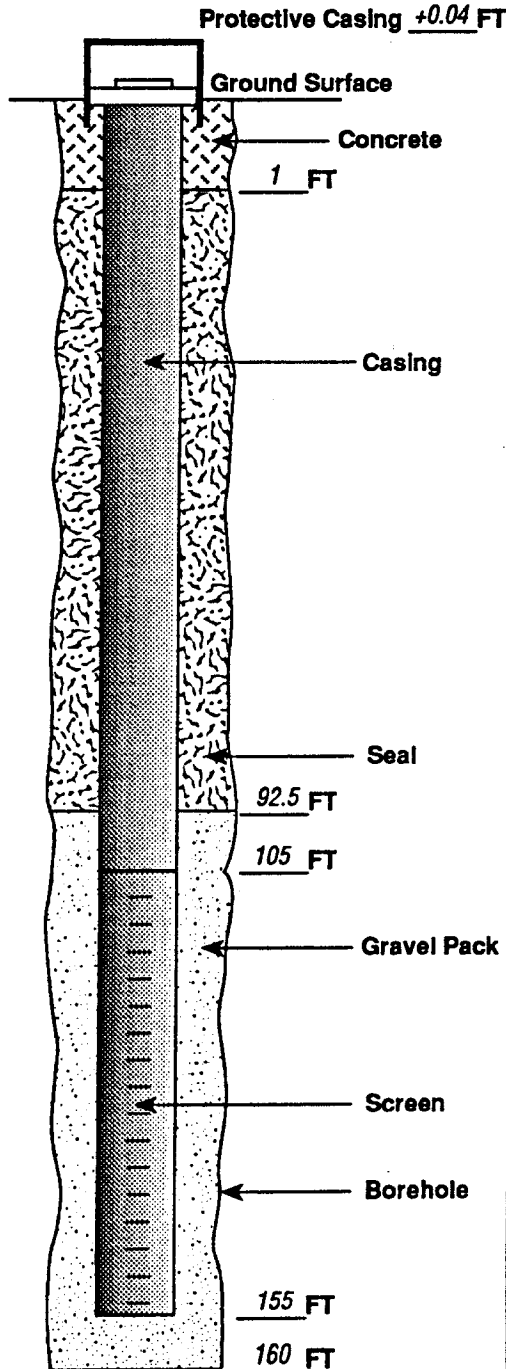
LOCATION: 4800 Oak Grove Dr.

SURFACE ELEV (ft above MSL): Approximately 1088.3

Pasadena, CA

CASING ELEV (ft above MSL): 1088.30

EBASCO PERSONNEL: B.G. Randolph / Rob Tweidt



DRILLING SUMMARY

DATE: 10/31/92

DRILLING COMPANY: Layne Environmental, Inc.

DRILLING FOREMAN: Steve Johnson

RIG TYPE: Portadrill 10 TLT-320

TOTAL DEPTH OF BORING: 160 feet

SURFACE CONDUCTOR CASING (length, diameter): None

DRILLING FLUID: Air

CONSTRUCTION LOG

WELL TYPE: Monitoring

BORING DIAMETER: 10.75 inches

TOTAL WELL DEPTH: 155 feet

CASING TYPE: Schedule 40 PVC (0' - 85')
Stainless Steel Type 304 (85' - 105')

CASING DIAMETER: 4 inches

CASING LENGTH: 105 feet

SCREEN TYPE: Stainless Steel Type 304

SCREEN SIZE: 0.010 inches

SCREEN LENGTH: 50 feet

TAILPIPE LENGTH: 0.32 feet

CASING STICKUP: +0.04 inches

PROTECTIVE CASING TYPE: DOT Approved Traffic Box

PROTECTIVE CASING STICKUP: 0.5 inches

CENTRALIZERS: None

SEAL MATERIAL: Enviroplug 1/4" Bentonite Pellets

SEAL VOLUME: 48.10 cubic feet

FILTER MATERIAL: RMC Lonestar #2/12 Sand

FILTER VOLUME: 35.65 cubic feet

COMMENTS: Concrete in top 1 foot

WELL MW-11

**BORING LOG AND WELL COMPLETION DIAGRAM
WESTBAY MP CASING INSTALLATION LOG**

EBASCO ENVIRONMENTAL

Monitoring Well 11

PROJECT Jet Propulsion Laboratory
 LOCATION South side of Building 277
 GEOLOGIST B.G. Randolph/R. Tweidt
 DRILLING CO Layne Environmental
 DATE (start/finish) 11/5/92 to 11/17/92

DRILLING METHOD Mud Rotary
 SAMPLING METHOD Grab samples
 SURFACE ELEVATION 1139.6'
 TOTAL DEPTH (ft) 700
 DEPTH TO WATER (ft) 118.52

Depth (ft)	Well Completion	Sample No.	OVA (ppm)			Lithology	USCS Symbol	Lithologic Description and Notes
			Samples	Drill Pipe	Sample			
0	LC Steel Surface Casing						SM	ASPHALT - Pavement (4 inches thick)
							SW	SILTY SAND (fill) - Silty fine to medium sand with some fine gravel, dark orange-brown, slightly moist, medium dense.
10	Cement/Bentonite		0	-	0		SW	GRAVELLY SAND - Gravelly fine to coarse sand, yellow-brown, slightly moist, dense.
							SP	Granitic boulder from 7' to 10'.
20	Volclay Grout							SAND - Medium to coarse sand with some fine sand and fine gravel, yellow-brown, slightly moist, dense, micaceous.
30	LC Steel Casing						GP	SANDY GRAVEL - Fine to coarse sandy gravel with occasional cobbles, yellow-brown, dense, micaceous.
								Cobbles and small boulders from 34' to 47'.
40	MW-II-1A MW-II-1B							
50							SP	GRAVELLY SAND - Gravelly fine to coarse sand with occasional cobbles, orange-brown to gray-brown, very dense, micaceous.
								Boulder from 55' to 58.5'.
60								Cobbles from 61.5' to 64'.
70							GP	SANDY GRAVEL - Fine to coarse gravel with cobbles and boulders, pale orange-brown and dark gray, very dense.
80								
90							SP	SAND - Fine to coarse sand with some gravel and occasional cobble, multi-colored sand grains and rock fragments, very dense.
								Fine to medium sand with trace silt, micaceous.
100	MW-II-2A MW-II-2B							Cobbles from 92' to 93.5'.
								Gravelly at 96'.

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 SAMPLING METHOD Grab samples
 SURFACE ELEVATION 1139.6'
 TOTAL DEPTH (ft) 700
 DEPTH TO WATER (ft) 118.52

Depth (ft)	Well Completion	Sample No.	Samples	OVA (ppm)			Lithology	USCS Symbol	Lithologic Description and Notes
				Drill Pipe	Sample	Breath Zn			
100	LC Steel Casing							SP	SANDY GRAVEL - Fine to coarse sandy gravel with occasional cobbles and small boulders, multi-colored grains, very dense.
110								GP	
120	304-SS Screen 1							SP	GRAVELLY SAND - Gravelly fine to coarse sand with occasional cobbles, multi-colored, very dense, micaceous. Boulder from 130' to 132'.
130								SP	
140	LC Steel Casing							SM	SILTY SAND - Silty gravelly fine to medium sand with occasional cobbles, orange-brown and multi-colored grains, very dense, micaceous. Cobbles from 148' to 150'.
150								SM	
160	LC Steel Casing							SP	SAND - Fine to medium sand with some silt and fine gravel, multi-colored grains, very dense. Gravelly sand at 177'.
170								SP	
180	LC Steel Casing							SM	Numerous cobbles and small boulders from 184' to 199'.
190								SM	
200	LC Steel Casing							SM	
								SM	

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DRILLING METHOD Mud Rotary
 SAMPLING METHOD Grab samples
 SURFACE ELEVATION 1139.6'
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Depth (ft)	Well Completion	Sample No.	OVA (ppm)			Lithology	USCS Symbol	Lithologic Description and Notes
			Samples	Drill Pipe	Sample			
200	LC Steel Casing						SM	SILTY SAND - Silty fine to medium sand with trace coarse sand, multi-colored, micaceous, very dense.
210								
220	LC Steel Casing						SP	SAND - Fine to medium sand with some gravel and trace silt, multi-colored, very dense.
230							SC	CLAYEY SAND - Clayey fine sand with some silt and trace medium sand, light yellow-brown, dense.
240	LC Steel Casing						SP	SAND - Fine to medium sand with trace coarse sand, light yellow-brown, micaceous, dense. Gravelly at 236'.
250								Medium to coarse sand.
260	LC Steel Casing						SM	SILTY SAND - Silty fine to medium sand with trace clay, yellow-brown, dense, trace mica.
270							SP	SAND - Fine to medium sand with trace silt and fine gravel, yellow-brown and multi-colored grains, very dense, micaceous.
280	LC Steel Casing						SM	SILTY SAND - Silty fine to medium sand, multi-colored, very dense, micaceous. Occasional gravel from 280' to 288'.
290								Silty fine sand with trace clay.
300		MW-11-3A MW-11-3B						Medium to coarse sand, trace gravel. Trace clay.

EBASCO ENVIRONMENTAL

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DRILLING METHOD Mud Rotary
 SAMPLING METHOD Grab samples
 SURFACE ELEVATION 1139.6'
 TOTAL DEPTH (ft) 700
 DEPTH TO WATER (ft) 118.52

Depth (ft)	Well Completion	Sample No.	Samples	OVA (ppm)		Lithology	USCS Symbol	Lithologic Description and Notes
				Drill Pipe	Sample			
300	LC Steel Casing						SM	Trace gravel.
310							SP SM	SAND AND SILTY SAND - Alternating layers of fine to medium sand and silty fine sand with trace clay, yellow-brown, very dense, and micaceous from 308' to 322'.
320	#2 1/2 Sand						SP	SAND - Fine to medium sand with trace silt and some fine gravel, multi-colored, very dense, micaceous. Occasional coarse gravel or small cobbles.
330							SM	SILTY SAND - Silty fine to medium sand with trace clay and fine gravel, multi-colored, very dense, micaceous. Cobbles at 336'.
340							SP	SAND - Fine to medium sand, yellow-brown, very dense, micaceous. Gravelly from 346' to 348'.
350							SM	SILTY SAND - Silty fine to medium sand with trace clay and coarse sand, multi-colored, very dense, micaceous.
360							SM SP	SILTY SAND AND SAND - Alternating layers silty fine sand with traces of clay and fine to medium sand with some silt and occasional gravel from 375' to 402', very dense, micaceous.
370								
380								
390								
400		MW-11-4A MW-11-4B						

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 SAMPLING METHOD Grab samples
 SURFACE ELEVATION 1139.6'
 TOTAL DEPTH (ft) 700
 DEPTH TO WATER (ft) 118.52

Depth (ft)	Well Completion	Sample No.	OVA (ppm)			Lithology	USCS Symbol	Lithologic Description and Notes
			Samples	Drill Pipe	Sample	Breath Zn		
400	LC Steel Casing						SM	SAND - Medium to coarse sand with some fine gravel and trace silt, multi-colored, very dense, trace mica. Gravelly.
410							SP	SILTY SAND - Silty fine to medium sand with trace clay, light yellow-brown, very dense, micaceous.
420	304-SS Screen 3						SP	SAND - Fine to medium sand with some gravel, light yellow-brown, very dense, trace mica.
430							SM	SILTY SAND - Silty fine to medium sand, multi-colored, very dense, micaceous.
440	LC Steel Casing						SP	SAND - Fine to medium sand with trace coarse sand and fine gravel, multi-colored, very dense, trace mica. Gravelly at 442'.
450							SM	SILTY SAND - Silty fine to medium sand with trace clay, light yellow-brown, very dense, micaceous.
460							SC	CLAYEY SAND - Clayey fine to medium sand with trace silty and fine gravel, light yellow-brown, very dense, trace mica.
470							SM	SILTY SAND - Silty fine to medium sand, light yellow-brown, very dense, micaceous.
480								Occasional thin lenses gravelly sand from 462' to 495'.
490							SC	CLAYEY SAND AND SANDY CLAY - Clayey fine to medium sand with silt, light orange-brown to dark gray-brown, very dense, trace mica.
500		MW-11-5A MW-11-5B						Gravel and cobbles from 498' to 502'.

EBASCO ENVIRONMENTAL

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DRILLING METHOD Mud Rotary
 SAMPLING METHOD Grab samples
 SURFACE ELEVATION 1139.6'
 TOTAL DEPTH (ft) 700
 DEPTH TO WATER (ft) 118.52

Depth (ft)	Well Completion	Sample No.	OVA (ppm)			Lithology	USCS Symbol	Lithologic Description and Notes
			Samples	Drill Pipe	Sample			
500	LC Steel Casing						SC	Trace coarse sand.
510								Occasional coarse gravel or small cobbles from 512' to 522'.
520	304-SS Screen 4'						SM	SILTY SAND - Silty fine to medium sand with trace clay and occasional fine gravel, multi-colored, very dense, micaceous.
530								Some coarse sand.
540	Bentonite Seal							Silty fine to medium sand. Gravel from 538' to 539.5'.
550								Silty fine to medium sand with some clay.
560	LC Steel Casing						GM	GRAVELLY SILTY SAND - Silty fine to medium sand with cobbles, multi-colored, very dense, trace mica.
570								Silty sand from 556' to 559'.
580	#2/12 Sand						SM	SILTY SAND - Silty fine to coarse sand with occasional gravel, multi-colored, very dense, micaceous.
590								Occasional cobbles from 569' to 576'.
600							GM	SILTY SANDY GRAVEL - Silty fine to medium sandy gravel with some coarse sand, multi-colored, very dense, trace mica.
								Occasional cobbles and boulders from 578' to 587'.
							SM SC	SILTY SAND - Silty fine to medium sand with some clay and trace coarse sand, multi-colored, very dense, trace mica.
								Clayey silty sand from 591' to 596'.

MW-II-6A
 MW-II-6B

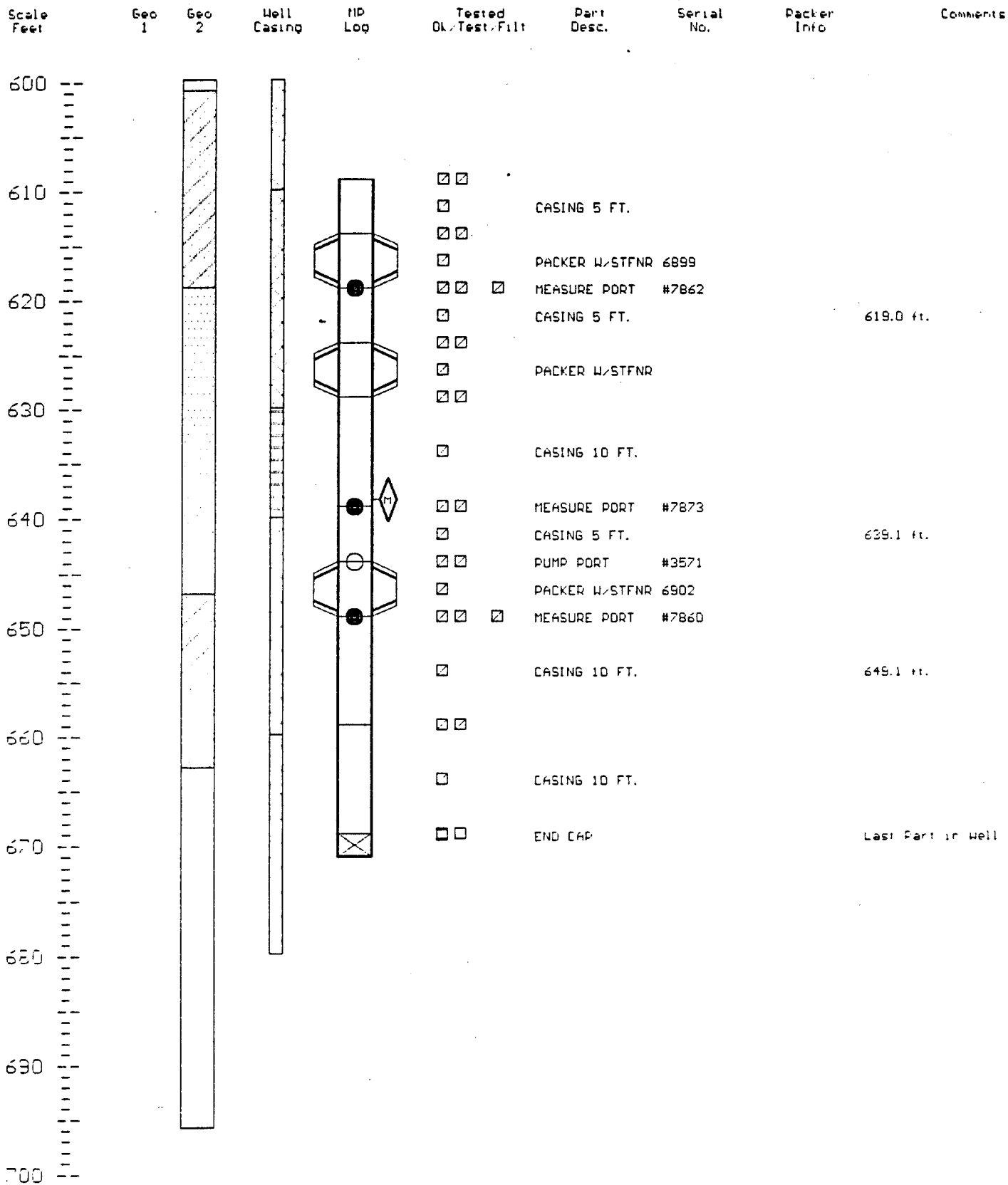
EBASCO ENVIRONMENTAL

Monitoring Well 11

PROJECT Jet Propulsion Laboratory
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 DATE (start/finish) 11/5/92 to 11/17/92

DRILLING METHOD Mud Rotary
 SAMPLING METHOD Grab samples
 SURFACE ELEVATION 1139.6'
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 DEPTH TO WATER (ft) 118.52

Depth (ft)	Well Completion	Sample No.	OVA (ppm)			Lithology	USCS Symbol	Lithologic Description and Notes
			Samples	Drill Pipe	Sample			
600	LC Steel Casing						SM SC	Some gravel from 601' to 603'.
610								Silty fine to medium sand.
620	304-SS Screen 5'						SM	SILTY SAND - Silty fine to medium sand with some coarse sand and trace clay, multi-colored, very dense, micaceous. Cobble at 623'. Gravelly from 624' to 626'.
630								Silty fine to medium sand with trace coarse sand. Occasional fine to coarse gravel from 632' to 638'.
640	LC Steel Casing							Small boulder at 638'. Silty fine to medium sand with some coarse sand and trace clay.
650							SC SM	CLAYEY SAND - Clayey silty fine to coarse sand, multi-colored grains, very dense, micaceous. Occasional small nodules (1/8-inch diameter) dark brown-gray to bluish-gray clayey silt.
660	Bentonite Seal							Occasional small nodules gray-brown and orange-brown fine sandy clayey silt. Clayey silty fine to medium sand with some coarse sand, micaceous.
670								Occasional small nodule dark orange-brown fine sandy clayey silt from 662' to 675'. Occasional gravel or small cobbles from 667' to 669.5'.
680	#2/12 Sand							Occasional gravel from 682' to 684'. Silty fine to coarse sand with clay and gravel from 684' to 687'.
690								Occasional gravel from 695' to 700'.
700		MW-11-7A MW-11-7B						Total depth = 700' Electric logs completed 11/11/92



Scale Feet	Geo 1	Geo 2	Well Casing	MP Log	Tested OK/Test/Filt	Part Desc.	Serial No.	Packer Info	Comments
0					<input type="checkbox"/> <input type="checkbox"/>	CASING 2 FT.			Top of MP no coup .32
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 2 FT.			MP Installed Nov 28.
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 5 FT.			All joints sealed 100%
10					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 5 FT.			one minute
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 5 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 10 FT.			Packers Inflated Nov.
20					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 10 FT.			
30					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 10 FT.			
40					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 10 FT.			
50					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 10 FT.			
60					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 10 FT.			
70					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 10 FT.			
80					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 10 FT.			
90					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 10 FT.			
100					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 10 FT.			

Scale Feet	Geo 1	Geo 2	Well Casing	HP Log	Tested Ok/Test/Filt	Part Desc.	Serial No.	Packer Info	Comments
100					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
110					<input checked="" type="checkbox"/>	CASING 10 FT.			
120					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
130					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	MEASURE PORT #7872			
					<input checked="" type="checkbox"/>	PACKER W/STFNR			124.3 ft
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	MEASURE PORT #7874			
					<input checked="" type="checkbox"/>	CASING 5 FT.			129.3 ft
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
					<input checked="" type="checkbox"/>	PACKER W/STFNR 6906			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
					<input checked="" type="checkbox"/>	CASING 10 FT.			
150					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	MEASURE PORT #7868			
					<input checked="" type="checkbox"/>	CASING 5 FT.			149.4 ft
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	PUMP PORT #3572			
					<input checked="" type="checkbox"/>	PACKER W/STFNR 6911			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	MEASURE PORT #7866			
					<input checked="" type="checkbox"/>	CASING 10 FT.			159.4 ft.
170					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
					<input checked="" type="checkbox"/>	CASING 10 FT.			
180					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 2 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	CASING 2 FT.			
190					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
200					<input checked="" type="checkbox"/>	CASING 10 FT.			

Scale Feet	Geo 1	Geo 2	Well Casing	MD Log	Tested OK/Test/Filt	Part Desc.	Serial No.	Packer Info	Comments
200					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
210					<input checked="" type="checkbox"/>	CASING 10 FT.			
220					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
230					<input checked="" type="checkbox"/>	CASING 10 FT.			
240					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
					<input checked="" type="checkbox"/>	PACKER W/STFNR			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	MEASURE PORT #7863			
					<input checked="" type="checkbox"/>	CASING 5 FT.			238.5 ft.
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
					<input checked="" type="checkbox"/>	PACKER W/STFNR 6908			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
250					<input checked="" type="checkbox"/>	CASING 10 FT.			
260					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	MEASURE PORT #7865			
					<input checked="" type="checkbox"/>	CASING 5 FT.			258.5 ft.
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	PUMP PORT #3592			
					<input checked="" type="checkbox"/>	PACKER W/STFNR 6909			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	MEASURE PORT #7651			
270					<input checked="" type="checkbox"/>	CASING 10 FT.			268.6 ft.
280					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
					<input checked="" type="checkbox"/>	CASING 5 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
290					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
300					<input checked="" type="checkbox"/>	CASING 10 FT.			

Scale Feet	Geo 1	Geo 2	Well Casing	NP Log	Tested Ok/Test/Filt	Part Desc.	Serial No.	Packer Info	Comments
300					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
310					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
320					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
330					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
340					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
350					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
360					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
370					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
380					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
390					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
400					<input checked="" type="checkbox"/>	CASING 10 FT.			

Scale Feet	Geo 1	Geo 2	Well Casing	HP Log	Tested Ok/Test/Filt	Part Desc.	Serial No.	Packer Info	Comments
400					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
410					<input checked="" type="checkbox"/>	PACKER W/STFNR			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	MEASURE PORT	#7864		
					<input checked="" type="checkbox"/>	CASING 5 FT.			406.7 ft.
420					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
					<input checked="" type="checkbox"/>	PACKER W/STFNR	6907		
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
					<input checked="" type="checkbox"/>	CASING 10 FT.			
430					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	MEASURE PORT	#7867		
					<input checked="" type="checkbox"/>	CASING 10 FT.			428.8 ft.
440					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	PUMP PORT	#3594		
					<input checked="" type="checkbox"/>	PACKER W/STFNR	6904		
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	MEASURE PORT	#7861		
					<input checked="" type="checkbox"/>	CASING 5 FT.			442.8 ft.
450					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
					<input checked="" type="checkbox"/>	CASING 10 FT.			
460					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
					<input checked="" type="checkbox"/>	CASING 10 FT.			
470					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
					<input checked="" type="checkbox"/>	CASING 10 FT.			
480					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
					<input checked="" type="checkbox"/>	CASING 10 FT.			
490					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
					<input checked="" type="checkbox"/>	CASING 10 FT.			
500					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
					<input checked="" type="checkbox"/>	PACKER W. STFNR	6890		

IB Pet. 650-92

Well EMW-11 JPL EBASCO

Scale Feet	Geo 1	Geo 2	Well Casing	HP Log	Tested Ok-Test-Filt	Part Desc.	Serial No.	Packer Info	Comments
500					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/>	MEASURE PORT	#7670		
					<input checked="" type="checkbox"/>	CASING 5 FT.			503.87 ft.
510					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
					<input checked="" type="checkbox"/>	PACKER W. STFNR	6900		
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
520					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	MEASURE PORT	#7671		
					<input checked="" type="checkbox"/>	CASING 10 FT.			523.9 ft.
530					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	PUMP PORT	#3593		
					<input checked="" type="checkbox"/>	PACKER W. STFNR	6901		
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/>	MEASURE PORT	#7669		
540					<input checked="" type="checkbox"/>	CASING 10 FT.			539.9 ft.
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
550					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
560					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
570					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
580					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
590					<input checked="" type="checkbox"/>	CASING 10 FT.			
					<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
600					<input checked="" type="checkbox"/>	CASING 10 FT.			

APPENDIX C

GEOPHYSICAL LOGS FOR JPL MONITORING WELLS